WATER SUPPLY PLAN

SEPTEMBER 2016

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ENGINEERING AND MANAGEMENT

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CITY OF OTHELLO
WATER SUPPLY PLAN

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TECHNICAL MEMO

TO: City of Othello, WA

FROM: Jesse Cowger, PE

DATE: August 24, 2016

RE: Water Supply Plan Summary

ATTACH: Water Supply Planning Recommendations – Aspect Consulting – Dec 10, 2014
Well Assessment – Aspect Consulting – Feb 12, 2016
Groundwater Supply Improvements – Aspect Consulting – Jun 21, 2016

Background

The City of Othello relies on wells drilled into the lower Wanapum Basalt aquifer as its sole source of drinking water. Over time the groundwater level in the lower Wanapum Basalt has declined and resulted in progressively lower pumping rates from existing wells. The Washington State Department of Ecology (Ecology) has identified and documented the regional decline of aquifer levels through a series of reports regarding the Columbia Basin Groundwater Management Area (GWMA). Othello recognized the looming threat to its water supply posed by declining aquifer levels and sought assistance from Varela & Associates and Aspect Consulting. The City tasked Varela and Aspect with developing a Water Supply Plan to secure the City's water supply for the future.

Othello received a Pre-Construction Grant from the Washington State Drinking Water State Revolving Fund (DWSRF) to partially fund the Water Supply Plan. The City utilized a combination of local funds and the grant from DWSRF to fund the Water Supply Plan.

Project Description and Scope

In addition to declining aquifer levels, interference between City and private wells exacerbates declining pumping rates in City wells. The City's Well 6 has fluoride (F) concentrations above the MCL and Well 7's capacity has declined possibly due to biofouling. The City also relies heavily on well pumping capacity to meet peak demands due to a lack of equalizing storage volume in reservoirs. Due to these factors, this Water Supply Plan scope includes the following:

- Systematic evaluation of existing wells
- Options for addressing fluoride level above MCL in Well 6
- Options for meeting present and future water demands

Systematic Evaluation of Existing Wells

Refer to attached Aspect Consulting memo dated February 12, 2016 for the full detailed analysis of City wells. The following summarizes the findings and recommendations related to the existing condition of the City's wells:

- The City is doing a good job of managing the effects of seasonal drawdown and well interference by selectively pumping certain wells to maximize yield.
- All City wells except Well 7 show stable well efficiency over time. Well 7 was constructed with a stainless steel screen (all other wells except Well 6 are completed primarily with open borehole in the water bearing zones. Rehabilitation of Well 7 might increase the existing pumping rate of 600 gpm to 900 gpm.
- The City operates a telemetry system collecting and recording water level and flow data from each of the active wells. Much of the historical telemetry data was reportedly corrupted and lost. Maintaining reliable, accurate water level and flow data is critical to managing and optimizing the City's pumping and limiting drawdown in the wells. We recommend that the City routinely archive telemetry data in a secure location to ensure data are available for future use.
- Wells 2, 6, and 8 may be subject to cascading water when pumping causes water levels to draw down below the elevation of uncased water bearing zones. Cascading water may entrain air and negatively affect pump performance. We recommend that the pump performance curves be compared to actual pump yields at operating total head to assess whether cascading water and air entrainment could be affecting pump performance.
- Water rights are not a constraint for the City in managing the well field. Withdrawals from recently constructed Well 9 are limited to 2,000 gpm, 3,000 ac-ft/year, as this well is only authorized under one City water right. We recommend that if and when future water changes are required that Well 9 be added to the right being changed.
- There is record in the files reviewed that proofs of appropriation or requests to extend the development schedules for City water rights were filed with Ecology. If this is the case, we recommend completing proofs of appropriation for five of the City's water rights that are ready for certification, while filing extensions to the development schedules for the remaining rights.

Options for Addressing Fluoride in Well 6

Well 6 has fluoride levels that generally exceed the MCL of 4.0 mg/L. The City attempted to modify the well in the past to decrease the fluoride concentration, but had little success. Due to the fluoride levels exceeding the MCL Othello currently designates Well 6 as an emergency well and only operates it if all other sources of supply cannot meet system demand. Well 6 is the City's largest producing source at 2,500 gpm. The City sees the following Options for future utilization of Well 6:

Option 1: Continue to Utilize Well 6 as an Emergency Source (Do Nothing)

The City can continue to utilize Well 6 on an emergency basis and rely on blending in the distribution system to dilute the fluoride level. The primary benefit of this alternative is no investment is required. This alternative has the disadvantage of lack of flexibility in when the City can utilize Well 6. It would also make it more likely the customers closest to Well 6 would consume water with fluoride levels that exceed the MCL. DOH may not allow the City to operate the well in the fashion indefinitely.

Option 2: Dedicate Well 6 to Supplying Industrial Users

More than half of the water pumped from Othello's wells goes to industrial users. The largest of these industrial users is Simplot, which utilizes roughly 70% of total industrial water supplied by Othello. If a significant portion of Othello's industrial users could utilize water from Well 6 without affecting their industrial processes, then devoting Well 6 to industrial use would effectively reduce the demand on Othello's other wells. The following considerations pertain to feasibility of implementing this option:

- DOH may have water quality requirements for the water used in the industrial processes that would preclude use of water with fluoride concentrations above 4.0 mg/L.
- Water produced from Well 6 has some aesthetic taste and odor issues that may make the water unappealing for some industrial customers.
- Dedicate use of Well 6 would require construction of a dedicated distribution system for industrial supply and would require industrial users to internally separate their potable uses from their industrial uses. This carries with it an increased risk of cross connection between the two systems.
- Well 6 does not currently have a VFD to allow modulation of pumping rate to match demand; however, the City has budgeted for purchase an installation of a VFD for Well 6.
- If the VFD does not provide sufficient range of flow for industrial users, then a dedicated reservoir would also be needed.
- Dedicating a single source to industrial use has potential for reliability issues if the single source breaks down. Installation of a one-way intertie with the City's potable water distribution system could potentially mitigate reliability concerns.

Additional discussions with the City's industrial users are needed to determine whether barriers exist that preclude implementation of this option. The City will investigate this option further and potentially combine discussions with industrial users while investigating the feasibility of industrial wastewater treatment and reuse.

Option 3: Construct Treatment System to Remove Fluoride from Well 6 Water

A Treatment system could remove fluoride from the water produced by Well 6. The following types of treatment methods could likely remove fluoride from Well 6 raw water to levels below the MCL:

- Granular Activated Alumina
- Reverse Osmosis (RO)
- Electrodialysis and Electrodialysis Reversal
- Bone Char

Additional investigation of the raw water properties and constituents is needed to determine which of the preceding treatment methods would make the most sense for Well 6 if implemented. A treatment system would require additional operator expertise and certification and would also have ongoing chemical and membrane/media expenses (depending on the treatment method).

Option 4: Blend Well 6 with other City Well(s)

Well 6 has the highest fluoride concentration of all Othello's wells. Most City wells have average fluoride concentrations around 2.0 mg/L; although some of the wells have occasional spikes up to 3.0 mg/L. Several factors affect the feasibility of blending Well 6 with another City well:

- Capacity: Well 6 is Othello's largest producing source with a current pumping rate of approximately 2,000 gpm. To reliably achieve a blended water fluoride concentration below the MCL the City may need to reduce the pumping rate of Well 6 to allow sufficient dilution of fluoride.
- Proximity of other wells to Well 6:
  - A dedicated main with no service connections is required to blend Well 6 with another well. The well closest to Well 6 is Well 2 which is approximately half a mile away. However, Well 2 has limited reliability; City Staff reports the well runs out of water after roughly 15 minutes of operation. The City has designated Well 2 "Emergency Only".
  - Due to Well 2's lack of capacity (historic pumping rate of approximately 300 gpm) compared to Well 6 and its lack of reliability for extended pumping, blending with Well 2 appears unfeasible.
  - Most City wells (other than Well 2) are 1-2 miles away from Well 6
- Reliability: in order to maintain blended fluoride concentration below the MCL operation of Well 6 becomes contingent upon the operability of the well(s) blended with it. If the blending well becomes inoperable due to mechanical failure, interference issues, capacity decline, or other issues then the City cannot operate Well 6 without supplying the system undiluted water with fluoride concentration likely exceeding the MCL.
- Monitoring: fluoride concentrations in City wells vary throughout the year so DOH would likely require routine monitoring (possibly daily) to demonstrate blended fluoride concentration meets regulatory requirements. The frequency and corresponding expense associated with monitoring blended water quality may affect the feasibility of this Option.

The cost associated with blending Well 6 with other City wells would be considerable due to the high capacity of Well 6 and its proximity to other wells. Blending also has the disadvantage of reduce reliability because Well 6 becomes dependent on the operation of other wells to achieve the desired blended fluoride concentration below the MCL.

Option 5: Use Well 6 as an Aquifer Storage and Recover (ASR) Injection Well

Othello has begun investigating the feasibility of developing a supplemental source of supply to augment its groundwater sources. The supplemental supply would likely include treatment of surface water and may utilize ASR (refer to later section of this memo for details pertaining to the City's plans for a future supplemental source of supply). If the City utilizes Well 6 as the injection well for ASR it may dilute the fluoride concentration in the vicinity of the well. If the City also continues to utilize Well 6 as a recovery well the fluoride concentration may drop below the MCL.

Well 6 is located near the western edge of Othello's system. Initial observations by the City's hydrogeology consultant indicate a well more centrally located betwixt Othello's other wells would be more ideal from an ASR standpoint. However, further analysis is needed to assess the options, combinations, advantages, and disadvantages associated with selecting the injection well(s) for an ASR system.

Utilizing Well 6 for ASR may have operational complexities that affect the well's availability for meeting system demand (e.g. when utilizing Well 6 as an injection well it cannot provide supply to the system). Some of the restrictions on availability could likely be overcome through operational coordination with the City's other wells and the new supplemental source (surface water or industrial). Presumably the City would not inject water during periods of high demand when the City might need Well 6 to meet peak demands.

Discussion of Options for Addressing Fluoride in Well 6

The following table summarizes advantages and disadvantages associated with the options for addressing fluoride in Well 6:

Option	Advantages	Disadvantages
1) Do Nothing	• Low cost	• Well 6 remains emergency source • Customers closest to Well 6 likely exposed to higher levels of fluoride when Well 6 operates
2) Dedicate Well 6 to Industrial Users	• Potentially puts capacity of Well 6 to use for existing industrial customers • Would likely reduce fluoride levels consumed by non-industrial customers	• Acceptability to regulators unknown • Would require dedicated distribution system and potentially storage facilities (significant cost to implement)
3) Treatment System to Remove Fluoride	• Reliable way to reduce fluoride from water produced by Well 6	• Likely significant first cost • Increased operational complexity • Ongoing chemical/media/membrane maintenance
4) Blend with other City Well(s)	• Could achieve blended fluoride levels that meet the MCL.	• Significant first cost associated with mains dedicated to blending • May required blending with multiple sources or reducing pumping rate of Well 6 • Reduces system reliability due to required functionality of blending wells to operate Well 6 • Increased monitoring to demonstrate blended water quality meets regulatory requirements

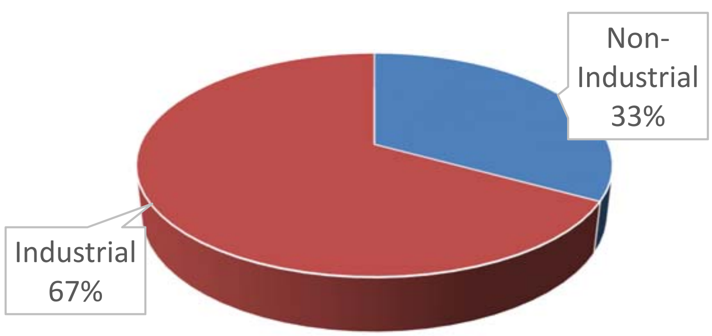
Option	Advantages	Disadvantages
5) Use Well 6 as ASR Injection Well	• May reduce concentration of fluoride in Well 6 to below MCL. • Would not require reducing the pumping rate of Well 6 • If ASR implemented, may slow the decline of the Wanapum aquifer • Supplemental source of supply would reduce the City's reliance on existing sole source aquifer	• Requires construction of supplemental source of supply (high first cost and ongoing operation and maintenance cost) • Non-central location of Well 6 in relation to Othello's other wells may not be ideal from an ASR standpoint • Greater operational complexity

As shown in the preceding table, each option has advantages and disadvantages. Additional investigation and cost estimates are needed to determine which option best serves the City's long-term interests. The results of the City's ASR feasibility study will affect the City's decision as will input from DOH on potentially devoting Well 6 to industrial use. Othello has begun the process of updating its Water System Plan and will further analyze the alternatives discussed herein when formulating the City's capital improvements plan.

Meeting Present and Future Water Demand

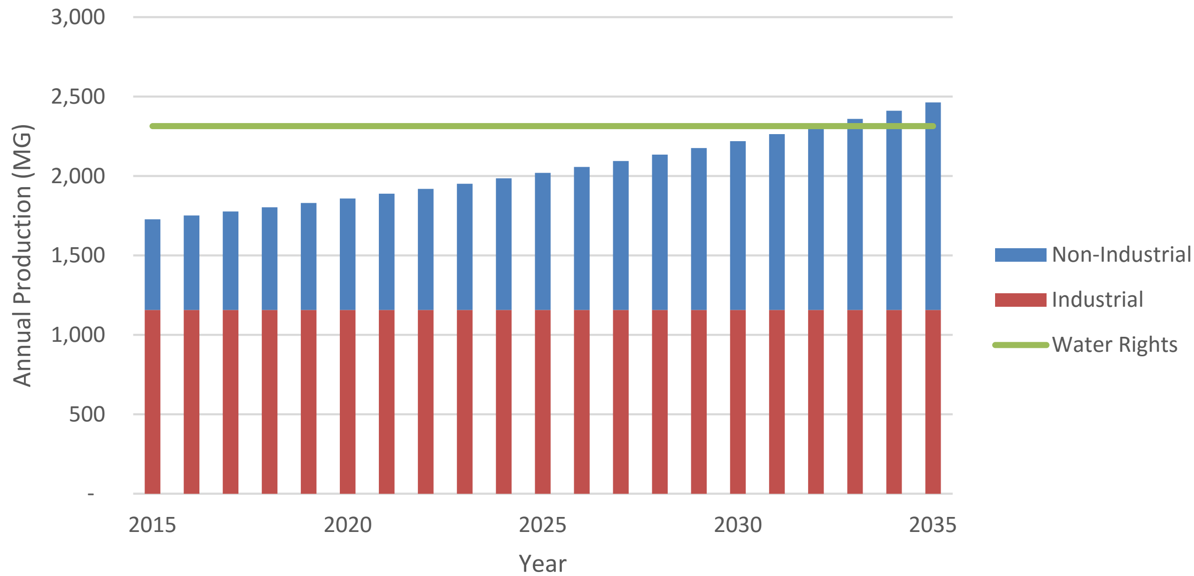
On March 28, 2016 Othello adopted its updated Comprehensive Plan (Comp Plan). The Comp Plan lays out an ambitious vision for growth in Othello which includes population growing from 7,780 in 2015 to 17,825 in 2035. The population growth projected in the Comp Plan equates to an annual rate of 4.23%. In many cases a water systems water demand will increase roughly proportionally to its population growth. However, Othello supplies several large industrial users which make up almost 2/3 of the City's annual demand. For this reason, projections for future demand can be broken into industrial and non-industrial segments.

Ratio of Industrial and Non-Industrial Water Use



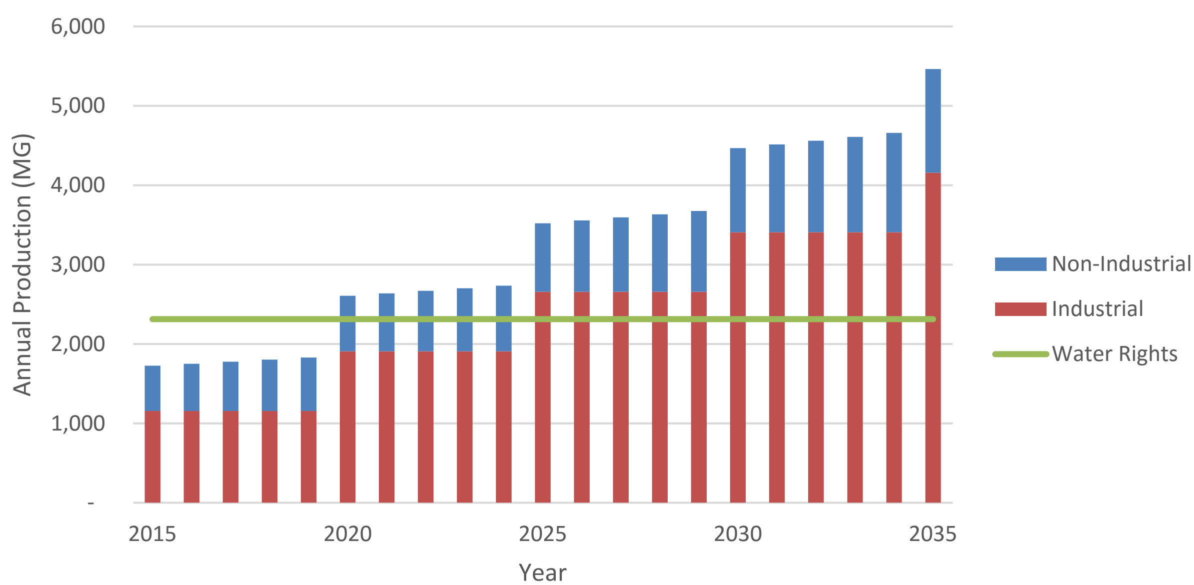
If non industrial water use increases proportionally with projected population growth and industrial demand remains static, the following demand curve results:

Projected Water Demand: No New Industrial Customers



Were Othello to attract additional industrial users to the City, water demand would experience incremental jumps as new industrial users come online. The City's largest industrial customer (Simplot) utilizes approximately 750 MG annually. If a new industrial user similar to Simplot located in Othello roughly every five years the following demand curve would result:

Projected Water Demand: New Industrial Customer Every Five Years



As shown in the preceding graphs, the time frame in which Othello has adequate water rights to meet system demand depends a great deal on whether the City attracts additional industrial users. If no new industrial users locate in the City then Othello's water rights could supply projected demand for the next 17-18 years. The City appears to have insufficient water rights to support addition of a new industrial user similar in size to Simplot at any point in the future. The City's

Comp Plan envisions growth of all sectors in Othello (residential, commercial, industrial, etc.); hence, the City plans the following steps to meet projected water demand and prevent availability of water supply from constraining growth in Othello:

Near Term: Continue to Maintain, Develop, and Rely on Groundwater

In the near term Othello must continue to rely on its groundwater sources and develop additional well(s) to keep up with regional declines in aquifer levels and corresponding declines in exiting well pumping rates. Refer to attached Aspect Consulting memo dated June 21, 2016 for the full detailed recommendations for improving Othello's groundwater supply. The following summarizes the findings and recommendations contained therein:

- Rehabilitate Well 7: it appears the efficiency of Well 7 has decreased over time. Rehabilitation of this well could recover 300 gpm of pumping capacity.
- Install new Wanapum Aquifer Well
- Explore Grande Ronde Aquifer

The City's existing wells tap the Wanapum basalt aquifer which has declined over time and decreased available drawdown and pumping rates of the City's wells. Rehabilitating Well 7 and developing a new Wanapum well will help the City maintain its existing supply capacity at least for the near term. Exploring the Grande Ronde basalt aquifer, which is deeper than the Wanapum basalt, will help the City determine the degree to which Othello may be able to rely on groundwater into the future. If the Grande Ronde has reasonable quality and quantity of water available it may extend the period of time Othello can continue to rely on groundwater supply.

Mid to Long-Term: Develop Supplemental Source of Supply

The available data and analyses to date document a regional decline in ground water levels in the Columbia Basin. The estimates vary on current rate of decline, but it appears Othello may not be able to continue to rely on groundwater indefinitely as its sole source of water supply. In recognition of the possibly finite nature of groundwater supply Othello plans to develop a supplemental source of supply. The City has identified the following possible components of a future supplemental source of supply:

- Surface water from bureau of reclamation irrigation canals treated to drinking water standards for potable use; this source could also be treated to the goundwater anti-degradation standard for injection and storage in the basalt aquifer for later recover via City wells.
- Industrial wastewater treated to anti-degradation standard for groundwater injection and storage in the basalt aquifer for later recovery via City wells. Currently industrial wastewater cannot be utilized for direct potable reuse; future changes in regulation may open doors for direct potable reuse of industrial wastewater.

The City has begun a study to investigate the feasibility of establishing a new source of supply which may employ aquifer storage and recovery (ASR) as a means to store treated water in the basalt aquifer. ASR may prove a useful tool for Othello due to several factors:

- Surface water from Bureau of Reclamation canals is not available for use during the winter. Treating water from the canals and storing it in the aquifer could allow Othello to treat and store the volume of water most useful to the City's situation.

- If the City pursued treatment and reuse of industrial wastewater the treated effluent would need to spend time in an environmental buffer such as a basalt aquifer before it could be utilized for drinking water.

- If the City utilizes Well 6 as the injection well for ASR it may dilute the fluoride concentration in the vicinity of the well (refer to previous discussion of options for Well 6). If the City also continues to utilize Well 6 as a recovery well the fluoride concentration may drop below the MCL.

Capacity of a supplemental source will depend on several factors including availability of raw water, construction and operation cost for treatment, and the City's desired ratio of groundwater Vs. supplement supply. Assuming availability of raw water is not the limiting factor, treatment could be designed for incremental expansion based on the City's needs over time.

The timing for implementation of a supplemental source of supply depends on many factors such as:

- Availability of raw water from Bureau of Reclamation canals, industrial users, or other sources not yet identified.

- Contaminants in raw water and treatment requirements to make raw water suitable for potable consumption or storage via ASR

- Permitting with Department of Ecology for reservoir permit and water rights implications

- Availability of funding

- Rate of aquifer decline and effect on Othello's ability to supply system demand

- Viability of Grande Ronde aquifer; if Grande Ronde is viable source of supply it may extend the timeframe Othello chooses to rely on groundwater

The results of Othello's ASR feasibility study will provide the City with some of the information needed to lay out a more specific timeline for implementation.

Aspect CONSULTING

MEMORANDUM

Project No.: 140207-002

December 10, 2014

To:	Wade Ferris, City Administrator City of Othello
From:	Joe Morrice, Associate Hydrogeologist Tim Flynn, Principal
Re:	**City of Othello Water Supply Planning Recommendations**

Aspect Consulting, LLC (Aspect) is under contract to the City of Othello (City) to provide strategic water supply planning support, including identifying and assessing short-term and long-term water supply options to support projected growth, while addressing potential future decline from the City's existing groundwater supply wells. This memorandum summarizes our review of current and projected water demands, expected future well source capacities and constraints, and recommended strategies to meet water supply demands. In preparing this memorandum we reviewed the City's Water System Plan (WSP) and reports prepared by the Columbia Basin Groundwater Management Area (GWMA) of Adams, Franklin, Grant, and Lincoln Counties, as well as discussed the current supply conditions and constraints and planning objectives with City staff.

Based on our review, the City faces shortfalls in system capacity to meet projected peak demands at some point in the future due to increasing demands and anticipated declines in water supply well yields. Demand projections, and more importantly projected decreases in well yields, are uncertain making predictions of when shortfalls could occur inexact. The GWMA reports imply shortfalls are imminent, while less conservative assumptions indicate shortfalls may not occur until about 2030. Given this range in estimates we recommend that for planning purposes the City should consider bringing additional capacity online and/or implementing other water supply strategies as discussed below over the next 5 to 10 years. These short- to mid-term actions would provide the City additional time to consider longer-term actions and to secure the regional partners and funding sources that may be required to implement these actions.

The following sections provide a summary of current and projected well yield and water demand conditions, the basis for the projected timelines of when shortfalls in system capacity may occur, and our recommendations for potentials actions by the City to secure water supply for future growth.

Current Conditions and Projected Future Conditions

Regional and Local Groundwater Conditions

The GWMA reports provide an assessment of regional groundwater supply conditions, a discussion of conditions focused on the Othello area, and estimates of water system (supply well) capacity for the City. There is a documented regional decline in water levels and yields for wells tapping the lower Wanapum Basalt aquifer, the primary source tapped by the City's wells. The observed decline in groundwater levels is related to the limited recharge received by the lower Wanapum Basalt aquifer, which is confined by a thick sequence of overlying basalt units. Withdrawals in excess of recharge have resulted in "mining" of water from the basalt aquifer, reducing water levels and available drawdown during pumping, in turn reducing well yields. Short term decline in yield in certain wells may also be attributable to seasonal pumping interference corresponding with the irrigation season (particularly during the months of July – September).

The draft 2014 GWMA Water Supply Alternatives Evaluation for the City (2014 GWMA draft report) describes decreases in water levels in the City's wells ranging from 1 to 10 feet per year with associated decreases in well pumping capacity of about 2 to 4 percent per year. The decrease in water levels is generally consistent with our independent assessment of water levels from the Wanapum Basalt in the Othello area. Our review indicates that water levels historically decreased by about 3 feet per year from about 1960 to 1990 increasing to about 10 feet per year between 2003 and 2008. The declines reflect both long-term regional aquifer depletion and seasonal drawdown interference due to concentrated pumping from the Wanapum Basalt in the immediate Othello area.

These estimates are rough approximations, based on limited data (typically the reported initial water level and yield compared to one or two recent measurements of yield and water level), and do not distinguish between seasonal interference and long-term declines. Lacking a more complete record of water level and yield data, these estimates are considered reasonable for generally assessing future supply conditions and comparing different supply options, but predictions of future yield based on these estimates should considered highly uncertain.

Water Demand Projections

The City's WSP and the 2014 GWMA draft report both provide estimates of current and projected future water demands and water system source capacities, although with different assumptions and levels of conservatism. Water demand projections and the potential for shortfalls in system capacity from these planning documents are summarized below.

City Water System Plan

The WSP provides details of the City's current water production and system capacity and projections of the water system demands through the year 2030. From 2005 through 2009 total water production equated to an average daily demand (ADD) of about 4 million gallons per day (gpd), or about 2,800 gallons per minute (gpm), continuously. The maximum day demand (MDD) over this period was about 6.6 million gpd, or about 4,580 gpm.

In 2009 about 61 percent of total water production is used to provide industrial supplies, with about 50 percent of all City water production going to one industrial customer (JR Simplot). A second industrial customer (McCain Foods) received about 5.6 percent of total City production in 2009, primarily during the summer months when McCain's water wells could not meet all their supply needs. The remaining 39 percent of total water production is primarily for residential and commercial use. Based on the usage categories tabulated in the WSP, apparent irrigation uses (listed as residential irrigation, outside residential, and commercial lawn) account for only about 5.7 percent of annual water production.

The WSP assumed annual population growth of 2.5 percent within the City limits and 2 percent in areas served by the City but outside City limits; no increase in industrial water use was assumed. The WSP also assumed no decrease in system capacity (i.e., well yields remain constant), although there is evidence of declining well yields. Two scenarios for projected MDD were presented. The first assumed continued reliance by McCain Foods to meet summer demands, with a demand of 1,300 gpm. The second scenario evaluated the effect on projected MDD assuming McCain Foods would no longer rely on City water for peak demands.

Assuming continued growth in population and commercial/residential water demands, no growth in industrial water demands, no reduction in well yield, and continued supply of 1,300 gpm of water to McCain Foods to meet peak demands the WSP projects system demands could exceed capacity by 2030, the end of the 20 year planning horizon. If McCain Foods no longer requires City supply to meet peak demands, the WSP projects 800 gpm of excess system capacity in 2030. With the exception of no reduction in future well yield, the other assumptions seem reasonable for planning purposes. Although not considered in the WSP, continued declines in the combined well yields of the City's water supply wells will shorten these timeframes. The effect of declining well yields on meeting system capacity is discussed in a later section of this memo.

2014 GWMA Draft Report Projections

The 2014 GWMA draft report provides projections of City water system demands and capacity for the years 2030 (same as the WSP) and 2060. These projections assume continued decreases in well yield of 2 to 4 percent per year and growth in population and water supply demand of 1.76 percent per year. The projections indicate a shortfall in the instantaneous capacity of the system to meet the MDD could occur as early as 2015. We consider this estimate to be very conservative, likely overstating the immediacy of potential water supply shortfalls, for the following reasons:

- The projections assume all water uses (e.g., industrial, residential, commercial) increase at the same rate as population growth of 1.76 percent per year. This is a reasonable estimate for growth in residential uses, but likely overestimates growth in industrial uses. Based on the WSP, approximately 61 percent of all current City water use is supplied to industrial users, of which over half is supplied to one industrial customer; unless that customer's demands grow at the same rate as population growth or significant new industrial users come on line, this assumption likely significantly overestimates growth in water system demands.
- The MDD estimates in this projection were selected as twice the average day demand (ADD), but information from the WSP indicates a MDD equal to 1.6 times the ADD. Typically as a water system grows the ratio between MDD and ADD decreases; using a value of 2 likely overestimates future peak use or MDD.
- The projections appear to be based on City water use data when supply was being provided to McCain Foods. For the past several years McCain Foods has received water from the City typically during the summer months when McCain Foods' water wells could not meet all their needs. McCain Foods is currently bringing additional water supply capacity online with construction of a well west of the City, and has approval from the Department of Ecology (Ecology) to construct a second well. This additional capacity should reduce demands on the City water system by as much as 1, 300 gpm during periods of peak demand, reducing the future MDD.

- The projected decreases in well yield of 2 to 4 percent per year does not account for the addition of pumping capacity at McCain Foods and the City's Well 9, each located several miles from existing McCain Foods and City wells. By spreading the pumping wells over a greater area seasonal water level drawdown interference during peak use may be reduced, in turn reducing the observed rate of decrease in water levels and yield.
- The projections do not account for increased capacity from the City's new Well 9 (although Well 9 is included in the subsequent evaluation of water supply alternatives).

By applying all of these conservative assumptions at once the predicted timeline for water supply shortfalls becomes extremely conservative with a high degree of uncertainty. As described in the following paragraphs, applying less conservative assumptions, which at a minimum include accounting for increased capacity from Well 9 and no increase or reduced future demand from industrial users (e.g., McCain Foods) produces a different timeline over which source capacity could be limiting, although future shortfalls during peak demands (i.e., summer months) still appear likely.

Based on source well production data in August 2014, a period representative of peak system demands, the City produced an average of about 5,310 gpm continuously from its wells. Assuming Well 9 will provide 1,000 gpm continuously when it is brought online, the system should be capable of producing a minimum of about 6,300 gpm to meet peak demands. The WSP estimated an MDD of about 5,800 gpm in 2010 with peak supply provided to McCain Foods and 4,500 gpm without supply to McCain Foods[1]. Assuming McCain Foods' increased water supply capacity eliminates their reliance on the City system to meet peak demands, the baseline MDD to project forward is about 4,500 gpm. Projecting this value forward, with a 1.76 percent per year growth in demand[2], and assuming no decrease in the City's water system capacity (i.e., no significant declines in well yield), the MDD could exceed system instantaneous capacity around 2030. Under a worst case scenario, if despite spreading the well sources over a greater area to reduce seasonal drawdown interference, yields continue to decline by the assumed 2 to 4 percent then demands could exceed system instantaneous capacity around 2017. We believe the latter scenario is unlikely to occur in such a short timeframe.

Based on the above, we do not consider the threat to the City's water system to be as imminent as described in the 2014 GWMA draft report; however it is likely at some point in the future, assuming continued growth in demand, that the City will experience a shortfall in system instantaneous capacity to meet MDD. For planning purposes the City should consider bringing additional capacity online and/or implementing other water supply strategies as outlined below over the next 5 to 10 years.

Recommendations

We recommend further evaluating a set of short-term to mid-term actions, leading to implementation of a subset of actions to address potential water supply needs. At the same time, we also recommend the City engage Ecology's Office of Columbia River (OCR) to initiate discussion

[1] The 2014 GWMA draft report used an MDD in 2010 of 5,500 gpm, presumably including supply to McCain Foods.

[2] As mentioned above, the population growth rate is expected to exceed the growth rate for total water system demands including industrial demands, making this a conservative assumption.

of potential long-term water supply strategies. Recommendations are based on review of the 2014 GWMA draft report and discussions with City staff. Actions would focus on improving reliability of existing sources, assessing and developing potential untapped sources (e.g., the Grande Ronde Basalt), and acquisition and exchange of groundwater sources held by others.

Implementing a set of the following recommendations may provide additional capacity to support on the order of 10 to 20 years of system growth, depending on the yield of any new sources developed. This would likely not be sufficient to address predicted shortfalls in system capacity in the longer-term projections provided by GWMA (e.g., projected 2060 demands), but as mentioned previously the projections are highly conservative and uncertain. These short- to mid-term actions would provide the City additional time to plan for longer-term actions that would likely be implemented on a regional scale, which would involve identifying regional private and public sector partners and funding sources.

Coordination of Pumping with Other Major Groundwater Users

McCain Foods is the primary other user of groundwater from the Wanapum Basalt in the immediate Othello area. There are indications that during peak summer demands drawdown interference between McCain Foods' wells and the City's wells reduces the yields for both. We recommend that the City engage with McCain Foods to coordinate well pumping with a goal of minimizing drawdown interference during summer demands and maximizing well production. This would require continuous water level and pumping monitoring of the City's and McCain Foods' wells, a capability that both parties currently have. Pumping and water level data would be used to adjust pumping rates and schedules to minimize drawdown interference and moderate the severity of localized pumping impacts to water levels and yield. This recommendation could be implemented with the existing SCADA system and would not require any infrastructure improvements. It would require limited effort on the part of the City to coordinate data gathering with McCain Foods with review of pumping and water level data by Aspect to provide recommendations for optimizing well operations.

Assess Viability of Grande Ronde Basalt

The Grande Ronde Basalt, which underlies the Wanapum Basalt, is largely undeveloped as a groundwater source in the Othello area. The Eastern Regional Office of Ecology treats the Wanapum Basalt and the Grande Ronde Basalt as the same source of water for water rights permitting, and it would be possible for the City to construct new wells tapping the Grande Ronde Basalt as additional points of withdrawal under its existing water rights. Potential well yield, water quality, and sustainability of the Grande Ronde near Othello is uncertain. We understand that the City's new Well 9 was drilled into the uppermost 190 feet of the Grande Ronde Basalt but did not encounter any significant water bearing zones. The most cost effective option for further assessing the Grande Ronde Basalts as a viable water supply option would be to advance an exploratory borehole through one of the City's existing large diameter wells. Next steps associated with further consideration of this option include identifying possible wells and viability of advancing a pilot hole (including potential well construction variance from Ecology) and refining the planning level costs to implement this option. Additional discussion with the City on the results of the Well 9 drilling is warranted to determine if further investigation of the Grande Ronde is worthwhile.

Tie-in to Port of Othello Well in Bruce

City staff identified the possible option of tying-in to the Port of Othello (Port) water well in Bruce, east of the City. The Port's Bruce Water System operates two wells reportedly capable of producing about 2,000 gpm from the lower Wanapum Basalt aquifer. This option would require negotiating a service agreement with the Port, extending a conveyance pipeline about 5 miles east from the City to the Port's water system, and permitting with Ecology. Permitting would include either supplying the City under the Port's water rights, requiring a change in place of use and possibly purpose of use of the Port's water rights, or adding the Port's wells to the City's water rights, requiring a change in the point of withdrawal to the City's water rights.

The advantages of this option are:

- It relies on existing wells with demonstrated capacity, reducing the risk and uncertainty associated with developing new supply wells.
- Water right permitting should be relatively straightforward, with options to provide supply under either the City's or the Port's water rights.
- As a stand-alone option costs for constructing a pipeline to the Port's wells may be prohibitive (on the order of $5 million, based on the planning level estimates in the GWMA report); however, a pipeline constructed for this option could also be used by other options to access water east of the City (additional groundwater supply wells or treated East Low Canal water), reducing the costs for developing additional sources of supply.

The primary disadvantage of this option is it may not be a permanent solution. It is unclear to what extent the Port's wells are experiencing the same decline in water levels and production as the City's wells, but given that the Port taps the same lower Wanapum Basalt aquifer as the City it is likely that these same issues will eventually affect the Port's wells. We recommend obtaining water level and well yield capacity data for the Port's wells to assess future sustainability. In addition we recommend assessing to what extent additional capacity may be realized from the Port of Othello's groundwater supply through source exchange using East Low Canal Supply. For example, if there are industrial clients served by the Port's groundwater well that could use canal water during peak summer demands, this could free additional groundwater source capacity.

Continued Development of Wanapum Basalt Aquifer in Areas East of the City

Similar to tying-in to the Port's wells and the City's recent construction of Well 9, the City could continue to develop additional groundwater capacity from the lower Wanapum Basalt aquifer east of the City. This options would require siting and drilling of a new well or wells, construction of conveyance pipeline, and permitting with Ecology to add the new wells as points of withdrawal to the City's water rights.

Siting well(s) east of the City would reduce seasonal drawdown interference with existing City wells during peak pumping demands. Depending on where a well can be sited this option could be combined with tying-in to the Port's Bruce Water System to share part of the conveyance pipeline costs. This shares the same disadvantage as tying-in to the Port's wells in that it is likely not a long-term solution to regional groundwater declines.

Source Exchange with Existing Groundwater Irrigation Right

The final option we recommend the City to consider is acquiring an existing groundwater right. This could include either direct purchase of the right and fallowing of the land or facilitating a source exchange to move an existing irrigator from groundwater to Bureau of Reclamation surface water from the East Low Canal. This option would require additional research to identify suitable rights, negotiation of the water right purchase and possibly support to secure alternate surface supply, permitting with Ecology, and construction of conveyance pipeline.

Depending on the location and condition of the source well for the acquired water right it could be tied-in to the City conveyance system or the City could drill a new well or wells and add them as points of withdrawal to the water right. It is likely any available water right will be for seasonal irrigation and would also require a change in place and purpose of use.

Similar to the options discussed above, acquiring a water right and well east of the City would reduce seasonal drawdown interference with existing City wells during peak pumping demands. Depending on where a well can be sited this option could be combined with tying-in to the Port's Bruce Water System and/or construction of new wells to share part of the conveyance pipeline costs. This shares the same disadvantages as tying-in to the Port's wells in that it is likely not a permanent solution to regional groundwater declines.

Longer-Term Actions with Regional Partners

Alternatives involving treatment of surface water from Potholes Canal or the East Low Canal or treatment of industrial wastewater for direct municipal or aquifer storage and recovery (ASR) uses include significant cost that are likely only viable as a component of a regional water supply strategy, such as a regional water supply augmentation project being developed by Ecology's Office of Columbia River (OCR) and the U.S. Bureau of Reclamation in the Odessa Subarea of the Columbia Basin Project. Although these actions have the potential to provide a large, secure, and reliable supply of water for future use, the expected high cost requires multi-user involvement. In addition to focusing on addressing near-term needs (5 to 10 year horizon), we recommend that the City meet with OCR to discuss and seek grant funding opportunities to explore long-term regional solutions (15 to 20 year horizon).

Limitations

Work for this project was performed for the City of Othello (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

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Aspect
CONSULTING

MEMORANDUM

Project No.: 150143

February 12, 2016

To: Jesse Cowger, PE, Varela & Associates, Inc.

State of Washington
Hydrogeologist
795
Licensed Geologist
Joseph N. Morrice

2-12-16

From:

Joe Morrice, LHG, CWRE Associate Hydrogeologist	Timothy Flynn, LHG Principal Hydrogeologist

Re: **City of Othello Water Supply Well Assessment**

This memorandum provides a review of the current conditions of the City of Othello's (City) eight existing water supply wells (Wells 2 through 9) with the purpose of assessing likely causes of well yield performance issues. This work was performed by Aspect Consulting, LLC (Aspect) under contract to Varela & Associates, Inc. (Varela).

There is a documented regional decline in water levels and yields for wells tapping the lower Wanapum Basalt aquifer, the primary source tapped by the City's wells. The observed decline in groundwater levels is in response to the collective regional pumping demand exceeding the limited recharge received by the lower Wanapum Basalt aquifer, which is confined by a thick sequence of overlying basalt units. Withdrawals in excess of recharge have resulted in "mining" of water from the basalt aquifer, reducing water levels and available drawdown during pumping, resulting in progressive declines in well yields. The declines reflect both long-term regional aquifer depletion and more local seasonal drawdown interference due to concentrated pumping from the Wanapum Basalt in the immediate Othello area.

Decreases in well yields are generally associated with two causes, assuming the pump is operating properly. First, as described above, decreases in aquifer water levels, either from the effects of regional withdrawals or more localized seasonal interference, will reduce available drawdown (the water column in the well above the pump inlet) and in turn well yield. The second potential cause is a loss of well efficiency, due to plugging or fouling of the well screen or aquifer formation. This will result in increased head losses as water enters the well from the aquifer, increasing the drawdown in the well and limiting the achievable yield.

Available information from the City and the Department of Ecology was reviewed to identify changes in the City's well yields and water levels over time and to assess the extent to which changes are likely due to loss of well efficiency or to declining aquifer water levels. Water level data from driller's logs and the City's telemetry system were used to assess changes in water levels over time. Changes in the estimated specific capacity of the wells was used as a surrogate for well efficiency. Specific capacity is defined as the pumping rate divided by the drawdown and is expressed in units of gallons per minute per foot of drawdown (gpm/ft). Assuming a constant pumping rate, drawdown in a well is a function of the pumping time. When comparing specific capacity values from different dates it is important to use drawdown values collected at the same time after the start of pumping for the comparison to be valid.

Most of the City's production wells were tested at the time they were constructed, either for short durations with increasing pumping rates or "steps" of 2 to 4 hours or longer durations of up to 24 hours at constant rates. For the most part, test results are only available from driller's logs, and typically include only the test duration, pumping rate, and final water level drawdown during pumping. Limited additional step rate or constant rate well test results are available for several wells that were modified or rehabilitated after construction. Additionally, the City's telemetry data were reviewed to identify data for each well when it had not been operated for a period of time and was then brought on-line. These data were used to estimate more recent specific capacity values for comparison to early tests.

The following sections provide a summary of results and recommendations, and discussion of the data and information reviewed to support the recommendations.

Summary of Conclusions and Recommendations

The following are conclusions and recommendations regarding loss in the City's well capacity based on available data:

- Loss in well capacity appears to be primarily related to longer-term, area-wide decline in groundwater levels, resulting in lower yields and higher pumping lift and requiring the City to reduce pumping to maintain sufficient water levels over the pump intakes. This interpretation is based on comparison of water levels at the times the wells were drilled and maximum water level recovery in the wells during lower demand periods in 2008 and 2015, the two years for which water level and pumping rate data are available from the City's telemetry system.
- Local drawdown interference between the City's wells appears to have a relatively minor impact on well yields, compared to the area-wide drawdown in groundwater levels. Drawdown interference between wells is seasonal and observed primarily when Well 6 is brought on-line to meet peak summer demands. Although seasonal pumping of Well 6 temporarily reduces yields from other wells (e.g., Wells 3 and 5), the high yield from Well 6 more than compensates for the production lost to drawdown interference.

- The City is doing a good job of managing the effects of seasonal drawdown and maximizing yield. Between 2008 and 2015 the City reduced the instantaneous pumping rate from Wells 3 and 5 by about one-third each and brought Well 6 on-line to meet peak seasonal demands. This has allowed Wells 3 and 5 to operate more continuously with less drawdown, without reducing peak or annual production capacity of the system as a whole.
- The City wells do not show an observable decrease in well efficiency over time based on review of specific capacity estimates, except for Well 7. This well was constructed with a stainless steel screen (all other wells except Well 6 are completed primarily with open borehole in the water bearing zones, with limited perforated casing sections) and has shown about a 50 percent loss in specific capacity since it was constructed in 1998. Yields have also declined, from about 1200 gallons per minute gpm when constructed to less than 1,000 gpm in 2008 and about 600 to 650 gpm in 2015. If about half the lost specific capacity can be recovered this well may sustain on the order of an additional 300 gpm. We recommend that the next time the pump is scheduled to be pulled for maintenance or inspection that the City include a video survey of the well, mechanical rehabilitation of the screen (e.g., surging, swabbing, brushing, jetting), and running a short-term step-rate pumping to assess the efficacy of well rehabilitation.
- The City operates a telemetry system collecting and recording water level and flow data from each of the active wells. Much of the historical telemetry data was reportedly corrupted and lost. Maintaining reliable, accurate water level and flow data is critical to managing and optimizing the City's pumping and limiting drawdown in the wells. We recommend that the City routinely archive telemetry data in a secure location to ensure data are available for future use.
- Based on well construction information and water levels during pumping, three City wells may be subject to cascading water as water levels are drawn down below the elevation of uncased water bearing zones. Pumping at Wells 2, 6, and 8 results in drawdowns of between 300 and 700 feet below the deepest cased sections of these wells. The driller's log for Well 2 does not provide descriptions of the materials encountered during drilling, but comparison of the logs and water level data for Wells 6, and 8 indicate potential uncased water bearing zones (e.g., fractured basalt) about 200 to 300 feet above the pumping water levels. If the pumping level is drawn down close to the pump intake, cascading water can entrain air and negatively affect pump performance. We recommend that the pump performance curves be compared to actual pump yields at operating total head to assess whether cascading water and air entrainment could be affecting pump performance.
- Water rights are not a constraint for the City in managing the well field. The City's eight water rights were consolidated in 2001, allowing exercise of all water rights (up to 9,550 gpm, 7,100 acre-feet per year [afy]) at Wells 2 through 8. Withdrawals from recently constructed Well 9 are limited to 2,000 gpm, 3,000 afy, as this well is only authorized under one City water right, but these limits are less than the yield and expected production from Well 9. The water rights as they currently exist do not significantly limit flexibility in managing the well field; however, we do recommend that if and when future water changes are required that Well 9 be added to the right being changed.
- The 2001 changes to consolidate the City's water rights included new development schedules for all rights, requiring that water be put to full beneficial use, a proof of

appropriation filed with Ecology, and the water rights be certificated by June 1, 2007. A subsequent change extended the development schedule for one water right (G3-25933P) to November 1, 2020. There is record in the files reviewed that proofs of appropriation or requests to extend the development schedules were filed with Ecology. If this is the case, we recommend completing proofs of appropriation five of the City's water rights that are ready for certification, while filing extensions to the development schedules for the remaining rights.

Review of Available Data

To evaluate likely causes for loss of well production Aspect reviewed data available from the City and the Department of Ecology (Ecology), including the following:

- Historical construction and maintenance information from the City's files;
- Drillers' well logs from the City's files and Ecology's database;
- Water level and pumping rate data from the City's telemetry system. Although the system has been in operation for years, much of the telemetry data was reportedly corrupted and lost, although it appears the system is now reliably collecting and storing data. Available data are limited to periods: September 24, 2007 through May 19, 2009 (referred to in this memo as the 2008 data) and November 4, 2014 through November 8, 2015 (referred to as the 2015 data). Telemetry data did not include Well 9 which was recently constructed.
- Water rights filed from Ecology's database.

Copies of well logs obtained from Ecology are provided in Attachment A.

Figures 1 through 14 provide graphs of the telemetry data from Wells 2 through 8. The graphs include production well water levels, pumping rates, and total system pumping (i.e., all wells combined) for the 2008 and 2015 data sets. Water level data were corrected to express water levels as elevation above mean sea level (msl) based on reported transducer set depth and surface elevation at well.

Table 1 provides a summary of well production in 2008 and 2015, including annual production per well in afy, annual production per well as a percent of total system production, and maximum instantaneous pumping rate by well in a given year. As shown by these data, in 2008 production was primarily from wells 3, 4, 5, 7, and 8, with limited production from Well 2. In 2015 Well 6 was brought on-line to meet seasonal demands, while pumping rates from Well 3 and 5 were reduced; note however that with a lower pumping rate Well 5 was able to provide a greater total annual production volume in 2015 than in 2008 as the City was able to operate it more continuously. Overall, changes in pumping schedules between 2008 and 2015 have allowed the City to increase total production by about 8 percent, while maintaining lower drawdowns and higher pumping levels.

Table 2 provides a summary of well construction, including subsequent modifications or rehabilitation efforts, based on review of City files and well logs from Ecology.

The following sections provide a well by well discussion of the construction and telemetry data relevant to assessing well yields, followed by a brief summary of the City's water rights. Specific capacity data discussed below are summarized on Table 3.

Well 2

Well 2 is located in the center of the City's well field. This well was constructed in 1940 and the driller's log contains limited information on well completion, water level, or original yield. In 2008 this well operated intermittently with a pumping rate of about 260 gpm and about 100 feet of drawdown. Well 2 was not operated in 2015. In 2008, with intermittent pumping, water levels were recovering to as high as about 650 feet msl, while in 2015 with no pumping of well 2 water levels only recovered to maximum elevation of about 610 feet, implying on the order of a 40 foot decrease in water levels within the City's well field over seven years. The 2015 data show the effect of local drawdown interference, with water levels in Well 2 decreasing by about 30 feet in response to seasonal pumping of Well 6 (represented by the sharp increase in combined system pumping starting in July).

Well 2 may be subject to cascading water when water levels are drawn down far below the elevation of uncased water bearing zones. When water levels are drawn down close to the pump intake, cascading water can result in air entrainment and less efficient pump performance, which would be observed as a lower yield at a given lift than if air were not entrained. The casing for Well 2 extends to 120 feet below ground surface, or an elevation of about 970 feet msl. Pumping water levels in 2008 were as low as 280 feet msl, or nearly 700 feet below the bottom of the casing. The well was not in operation in 2015, and non-pumping water levels were as low as 570 feet. The driller's log for Well 2 does not describe the geologic conditions or water bearing zones, but the large elevation difference between the bottom of the casing and the pumping water levels makes cascading water a possibility.

Well 3

Well 3 is located in the center of the well field, about 1/2 mile northeast of Well 2. This well was constructed in 1957, and reconditioned and equipped with a new pump in 1977. Depth to water in 1957 was reported as 278 feet, or an elevation of about 837 feet msl. In 1977, after reconditioning the well, depth to water was reported as 385 feet, or an elevation of 730 feet msl. The 2008 water level telemetry data for Well 3 are suspect, given the "flat line" readings starting in March 2008, however the 2015 data show that maximum, non-pumping water levels in Well 3 had declined to about 570 feet msl. These data imply long-term declines in water levels at Well 3 of about 110 feet between 1957 and 1977 and about 160 feet between 1977 and today.

When tested in 1957, Well 3 produced 1,340 gpm with 36 feet of drawdown; no test duration was reported. After reconditioning in 1977, Well 3 was tested at rates of 1,263, 1,463, and 1,714 gpm, with drawdowns of 58, 76, and 100 feet, respectively. Each pumping "step" was performed for a duration of two hours. The 1977 pumping rates and drawdowns equate to specific capacities of about 17 to 22 gpm/ft.

The 2015 data can be used to estimate current specific capacity, which in turn provides indications about whether loss of well yield is related to declining water levels or poor well efficiency. Well 3 was put into production at the end of February 2015, after a period of limited use. Telemetry data shows that at a pumping rate of about 900 gpm the water level decreased by about 50 feet in two hours. These values correspond to a specific capacity of 18 gpm/ft, which is in line with the specific capacities estimated from the 1977 test. Based on these data, loss of yield from Well 3 is likely not related to loss of efficiency of Well 3 (e.g., due to fouling or blocking of water-bearing fractures) but instead is related to the long-term decrease in area-wide water levels.

Well 4

Well 4 is located on the southeast side of the well field and was constructed in 1965 to a total depth of 905 feet. The well was lined with casing to a depth of 826 feet, which was perforated between 550 and 795 feet. In 1992 Well 4 was deepened to 1,450 feet and the casing removed from 443 to 826 feet. In 1994 the lower boring was backfilled below a depth of 994 feet to seal off apparent upflow from the Grande Ronde Basalt. The remaining casing between 428 and 436 feet was perforated. Currently, the well has casing extending from surface to 443 feet and is open borehole from 443 feet to the total depth of 994 feet.

In 1965 the depth to water was reported as 225 feet, or an elevation of about 870 feet msl. In 1992, following deepening of the boring and casing removal, depth to water was reported as 403 feet, or an elevation of about 692 feet msl. In 1994, following backfill of the lower portion of the boring, depth to water was reported as 386 feet, or an elevation of about 709 feet msl. These data imply long-term declines in water levels at Well 4 of about 160 feet between 1965 and today.

The telemetry data show that maximum, non-pumping water levels in Well 4 have increased since 1994 to 825 feet msl in 2008 and 860 feet msl in 2015, but remain about 10 to 50 feet below the water level in 1965. The recovery in water levels since 1994 is likely due to reduced pumping rates at Well 4, resulting in less drawdown in the immediate area around the well.

When tested in 1965, Well 4 produced 1,000 gpm with 25 feet of drawdown after 20 hours, for a specific capacity of 40 gpm/ft. In 1992, following well deepening and partial casing removal, Well 4 was tested at a rate of 1,375 gpm with 44 feet of drawdown after 24 hours, for a specific capacity of 31 gpm/ft (CH2M HILL, 1992).

Well test records following the 1994 backfilling of the lower borehole were not found, but a letter to Department of Health (Gray and Osborne, 1994) discussing results of the test implies on the order of 100 feet of drawdown after pumping at a rate of 1,400 gpm for 24 hours, for a specific capacity of roughly 14 gpm/ft. Well 4 was put into production in November 2007 after a period of limited use. Telemetry data shows that at a pumping rate of about 510 gpm the water level decreased by about 40 feet after 24 hours, for a specific capacity of about 13 gpm/ft. This specific capacity is similar to the value estimated from the 1994 test, and indicates no appreciable loss in well efficiency since the well was modified.

Well 5

Well 5 is located on the south end of the City’s well field. This well was constructed in 1974 to a total depth of 1007 feet and was reconditioned in 1987. The well was constructed with casing from ground surface to a depth of 666 feet, and perforated from depths of 550 to 650 feet.

Depth to water in 1974 was reported as 283 feet, or an elevation of about 769 feet msl. In 1987, after reconditioning the well, depth to water was reported as 277 feet, essentially the same as in 1977. In 2008 maximum non-pumping water levels at Well 5 were about 675 feet msl. Only very brief periods of non-pumping were recorded in 2015, with maximum water levels of about 600 feet msl. These data imply water level decreases of about 100 to 170 feet since 1974.

When tested in 1977, Well 5 produced 1,575 gpm with 148 feet of drawdown after 12 hours, for a specific capacity of about 11 gpm/ft. In 1987, following well reconditioning, Well 5 was tested at rates of 1,175, 1,590 , and 1,740 gpm, with drawdowns of 56, 117, and 160 feet, respectively. Each pumping “step” was performed for a duration of four hours. The 1987 pumping rates and drawdowns equate to specific capacities of about 11 to 21 gpm/ft. Although the specific capacity values are not directly comparable to the 1977 test given the different pumping durations, these data imply that, following reconditioning, Well 5 had not experienced a decrease in efficiency.

Well 5 was pumped intermittently in 2008, with instantaneous production rates of about 1200 to 1400 gpm. In 2015, production was near continuous with a rate of 850 to 1000 gpm; pumping levels and yields decreased by about 40 feet and 150 gpm when well 6 was brought on-line and combined system pumping increased in July 2015.

Well 5 was put into production in April 2008 after about two months of nonuse. Telemetry data show that at a pumping rate of about 1,400 gpm the water level decreased by about 120 feet after 12 hours, for a specific capacity of about 12 gpm/ft. This specific capacity is similar to the values estimated from the 1977 and 1987 tests, and indicates no appreciable loss in well efficiency since the well was constructed and reconditioned.

Well 6

Well 6 is located on the west side of the City’s well field. This well was constructed in 1978 to a total depth of 1,120 feet. The well was originally constructed with permanent, cemented casing from ground surface to a depth of 212 feet, and a liner with screen assembly extending to total depth. The screen assembly included stainless steel screen sections between depths of 1,015 and 1,075 feet. The well was modified in 2011 by removing the screen assembly and grouting the lower bore hole from total depth to 1,002 feet bgs. The well is currently completed as open borehole from depths of 212 feet to 1,002 feet.

In 1978 the depth to water was reported as 197 feet, or an elevation of about 856 feet msl. In 2011, during modifications to the well, depth to water was reported as 536 feet, or an elevation of about 517 feet msl. Telemetry data from 2008 and 2015 show water levels recovering to maximum elevations of about 630 and 610 feet msl, respectively. Given the different well completion depths and presence or absence of screens when each of these water levels were measured, direct comparison of the water levels over time is not meaningful.

When first constructed, Well 6 was tested at a rate of 2,500 gpm and exhibited about 40 feet of drawdown after about 17 hours, or a specific capacity of about 63 gpm/ft. After the well was modified in 2011, it was tested at a rate of 2,000 gpm and showed 60 feet of drawdown after 12 hours, or a specific capacity of about 33 gpm/ft. It is likely that abandoning the lower borehole reduced the yield from this well.

In 2008, Well 6 was not in operation. In 2015, Well 6 was brought into production in early July after several months of nonuse. Telemetry data show that at a pumping rate of about 2,500 gpm the water level decreased by about 70 feet after 12 hours, for a specific capacity of about 36 gpm/ft.

This specific capacity is similar to the value estimated from the 2011 test, and indicates no appreciable loss in well efficiency since the well was modified.

Well 6 may be subject to cascading water when water levels are drawn down below the elevation of uncased water bearing zones. The casing for Well 6 extends to 212 feet below ground surface, or an elevation of about 840 feet msl. The well was not in operation in 2008, and non-pumping water levels were as low as 550 feet. Pumping water levels in 2015 were as low as 500 feet msl, or about 340 feet below the bottom of the casing. The driller's log for Well 6 indicates potential water bearing zones (fractured basalt) at elevations as high as 710 feet msl, below the bottom of the casing and about 210 feet above the pumping water level. If significant water is entering the well through the upper water bearing zone cascading water and associated impacts to pump efficiency are a possibility.

Well 7

Well 7 is located on the south end of the City's well field and was constructed in 1998. The well was drilled to depth of 820 feet, and was completed with a liner and screen assembly extending to total depth. Screen sections were installed between depths of 670 and 740 feet and between 795 and 815 feet.

In 1998, depth to water was reported as 125 feet, or an elevation of about 895 feet msl. Well 7 was operated intermittently in 2008 and more continuously in 2015. During periods of non-pumping, water levels rose to maximums of about 860 to 870 feet msl, a decrease of about 25 to 35 feet from the water level when the well was first completed.

When first constructed, Well 7 was tested at rates of 950 gpm and 1,200 gpm, with reported drawdowns of 245 and 290 feet, respectively, after 4 hours. These equate to specific capacities of about 4 gpm/ft. In 2008 Well 7 operated intermittently at rates of about 800 to 1,000 gpm and in 2015 operated near-continuously at rates of about 650 to 700 gpm. In January 2008, Well 7 was brought online after several days of nonuse. Pumping at a rate of 1,000 gpm the well showed about 380 feet of drawdown in four hours, for a specific capacity of about 2.7 gpm/ft. Similarly, in April 2015, Well 7 was brought online after several days of nonuse. Pumping at a rate of 700 gpm the well showed about 360 feet of drawdown in four hours, for a specific capacity of about 1.9 gpm/ft.

Although data are limited, it appears that Well 7 has suffered some loss of efficiency and may benefit from well screen rehabilitation. Based on the average 2015 pumping rate of about 650 gpm, if screen rehabilitation can restore half the lost specific capacity (i.e., increase it from 2 to 3 gpm/ft), then Well 7 could produce on the order of an additional 300 gpm with the current drawdown and pumping lifts.

Well 8

Well 8 is located on the north end of the City's well field and was constructed in 2002. The well was drilled to depth of 951 feet, and was completed with casing extending to 398 feet and open borehole below that depth.

In 2002, depth to water was reported as 380 feet, or an elevation of about 739 feet msl. Well 8 was operated intermittently in 2008 and 2015. During periods of non-pumping, water levels rose to maximums of about 630 feet msl, a decrease of about 110 feet from the water level when the well was first completed.

When first constructed, Well 8 was tested at an average rate of 923 gpm, with reported drawdown of about 200 feet after 24 hours. This equates to specific capacity of about 4.6 gpm/ft. In 2008 Well 8 operated at rates of about 600 to 1,000 gpm and in 2015 the well operated at rates of about 400 to 450 gpm. In December 2007, Well 8 was brought online after about two months of nonuse. Pumping at a rate of 780 gpm the well showed about 200 feet of drawdown in 24 hours, for a specific capacity of about 3.9 gpm/ft. Similarly, in February 2015, Well 8 was brought online after several days of nonuse. Pumping at a rate of about 500 gpm the well showed about 160 feet of drawdown in 24 hours, for a specific capacity of about 3.1 gpm/ft.

These specific capacity estimates imply a potential modest loss of efficiency at Well 8 that may be reducing yields. However, the approximately 110 foot decrease in water levels since the well was first constructed is likely the primary reason for reduced well yields.

Well 8 may be subject to cascading water when water levels are drawn down below the elevation of uncased water bearing zones. The casing for Well 8 extends to 398 feet below ground surface, or an elevation of about 720 feet msl. Pumping water levels in 2008 and 2015 were as low as 350 and 450 feet msl, respectively. The driller's log for Well 8 indicates potential water bearing zones (fractured basalt) at elevations as high as 670 feet msl, below the bottom of the casing and about 320 feet above the lowest pumping water level. If significant water is entering the well through the upper water bearing zones, cascading water and associated impacts to pump efficiency are a possibility.

Well 9

Well 9 was constructed in 2015 approximately two miles east of the City's main well field and is planned to be tied-in to the City's distribution system. The well was tested at a constant rate of 1,480 gpm and showed about 175 feet of drawdown after 24 hours. This equates to a specific capacity of about 8.5 gpm/ft. Based on well testing, pump station was designed to provide about 1,500 gpm.

Water Rights

Water rights do not present a constraint to operation of the City's well field, including new Well 9. The City holds eight water right certificates and permits, authorizing combined instantaneous and annual withdrawals of 9,550 gpm, 7,100 afy (Table 4). Originally, the water rights authorized withdrawal from one City well each. In 2001 the City completed water right changes, consolidating the rights to allow withdrawals under any right from Well 1 through 7 and planned Wells 8 through 10. Well 8 has since been constructed and brought on-line. Planned Well 10 has not been constructed.

A subsequent water right change was processed through the Adams County Conservancy Board (Board) for permit G3-25933P, requesting to change the location of proposed Well 9. The change was approved by the Board and affirmed by Ecology in January 2014. Well 9 was constructed at the newly approved location in 2015 about two miles east of the City; use of this well is only authorized under water right permit G3-25933P, and has not been added to the City's other water rights.

As currently authorized, the City is permitted to withdraw 9,550 gpm, 7,100 afy from Wells 2 through 9, with the limitation that Well 9 can withdraw no more than 3,000 gpm and 2,000 afy. This does not present a significant constraint on system flexibility or exercise of the water rights. Permit G3-25933P was issued with no primary annual quantity, meaning annual withdrawals under this right are charged against any or all other primary rights in the City's water rights portfolio. Additionally, Well 9 is designed to produce 1,500 gpm and is not expected to exceed either the 3,000 gpm instantaneous or 2,000 afy annual withdrawals authorized by this right. However, for clarity in tracking and reporting water usage under its rights, we recommend adding the actual location of Well 9 as a point of withdrawal to the City's other water rights if and when future permitting decisions are pursued through Ecology or the Board.

In approving the 2001 water right changes, Ecology included development schedules to put water to full beneficial use and file proof of appropriation to certificate the rights by June 1, 2007. In the 2014 change decision for G3-25933P Ecology included a development schedule to put water withdrawn under this right to full beneficial use by November 1, 2020. No records were found in the file review to indicate that proofs of appropriation or requests to extend the development schedules have been filed with Ecology. If this is the case, we recommend the City file proofs of appropriation documenting beneficial use of water and/or requesting extensions to the development schedules.

Given recent City water production of about 5,400 afy, water rights 182-D, 183-D, 3390-A, 5338-A, and G3-20368P, with total combined authorized annual withdrawals of 5,270 afy (3,024 afy primary), could be certificated now. This would require filing the proofs of appropriation with Ecology, and then contracting a Certified Water Right Examiner (CWRE) to complete the proof field examination with a recommendation to Ecology as to what quantities to certificate. Aspect has several state-licensed CWREs who could complete the field examinations.

Based on recent usage, water rights G3-25032P, G3-25033P, and G3-25933P are not be ready for certification at the full quantities approved in the permits, until that water has been fully put to beneficial use. We recommend requesting extensions to the development schedules for rights G3-25032P and G3-25033P, with requested development schedules based on projected growth in water demands from the City's most recent Water system Plan, rather than an arbitrary six year period as was previously approved. Typically Ecology will grant a schedule extension if the water right holder has in compliance with the water right permit requirements, has shown due diligence in pursuing development of the right, and is not speculating on water supply for profit. The City should meet each of these criteria.

References

Gray and Osborne, 1994. City of Othello, Completion of repairs to Well No. 4, Washington, Letter to Scott Torpie, P.E., Washington State Department of Health. March 21.

CH2M HILL, 1992. Source testing, Well No. 4, Prepared for City of Othello. May.

Limitations

Work for this project was performed for the Varela Associates (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Attachments

Table 1 – Well Production Summary

Table 2 – Well Construction Summary

Table 3 –Specific Capacity Summary

Table 4 – Water Rights Summary

Figure 1 – Well 2 Production and Water Levels, 2008

Figure 2 – Well 2 Production and Water Levels, 2015

Figure 3 – Well 3 Production and Water Levels, 2008

Figure 4 – Well 3 Production and Water Levels, 2015

Figure 5 – Well 4 Production and Water Levels, 2008

Figure 6 – Well 5 Production and Water Levels, 2015

Figure 7 – Well 5 Production and Water Levels, 2008

Figure 8 – Well 5 Production and Water Levels, 2015

Figure 9 – Well 6 Production and Water Levels, 2008

Figure 10 – Well 6 Production and Water Levels, 2015

Figure 11 – Well 7 Production and Water Levels, 2008

Figure 12 – Well 7 Production and Water Levels, 2015

Figure 13 – Well 8 Production and Water Levels, 2008

Figure 14 – Well 8 Production and Water Levels, 2015

Attachment A – Driller's Well Logs

TABLES

Table 1 - Well Production Summary

150143 - City of Othello, Washington

		Well Number							
Year	Parameter	2	3	4	5	6	7	8	Total
2008	Annual Production (af)	249	1,380	696	1,155	36	817	447	4,781
	Average Withdrawal Rate (gpm)	155	855	432	716	23	506	277	2,964
	Percent of Annual Production	5%	29%	15%	24%	1%	17%	9%	100%
2015	Annual Production (af)	5	885	635	1,530	640	973	496	5,164
	Average Withdrawal Rate (gpm)	3	548	394	949	397	603	307	3,201
	Percent of Annual Production	0%	17%	12%	30%	12%	19%	10%	100%

Notes:

af - acre-Feet

gpm - gallons per minute

Table 2 - Well Construction Summary

150143 - City of Othello, Washington

Well Number	Construction/ Modification Date	Total Depth	Depth of Screened or Perforated Casing Intervals (feet)	Depth of Open, Uncased Intervals (feet)	DTW (feet)	DTW Date	Modification Work
2	1940	697	Not reported	120 to 697	Not Reported	Not Reported	
3	1957	900	None	197 to 900	278	2/1/1957	
	1977	No change	No change	No change	385	5/11/1977	Reconditioned well, new pump
4	1965	905	550 to 795	826 to 905	225	1/30/1965	
	1992	1,450	None	443 to 1450	403	5/18/1992	Deepened, pulled casing
	1994	976	428 to 436	443 to 976	396	1/11/1997	abandon lower borehole, perforate casing
5	1974	1,007	550 to 650	666 to 1,007	283	12/19/1973	
	1987	No change	No change	No change	277	3/31/1987	Reconditioned well
6	1978	1,210	1,015 to 1,075	None	197	1/25/1978	
		1,002	NA	212 to 1,002	536	2/22/2011	abandon lower borehole, pull screen assembly
7	1997	820	670 to 815	NA	125	5/13/1997	
8	2002	853	NA	398 to 853	380	11/18/2002	
9	2015	1,042	418 to 1,040	NA	51	5/27/2015	

Notes:
DTW - depth to water

Table 3 - Specific Capacity Summary

150143 - City of Othello, Washington

Well Number	Date	Source of Data	Pumping Rate (gpm)	Drawdown (feet)	Test Duration (hours)	Specific Capacity (gpm/ft)	Notes
2	1940	Driller's Log	No data provided on driller's log				
3	1957	Driller's Log	1,340	36	Not reported	37	
	1977	Driller's Log	1,263	58	2	22	Well reconditioned
			1,463	76	2	19	
			1,714	100	2	17	
	2015	City telemetry	900	50	2	18	
4	1965	Driller's Log	1,000	25	20	40	
	1992	CH2M HILL	1,375	44	24	31	Well deepened, casing removed
	1994	Gray & Osborne	1,400	100	24	14	Abandon lower borehole, perforate remaining casing
	2007	City telemetry	510	40	24	13	
5	1977	Driller's Log	1,575	148	12	11	
	1987	Driller's Log	1,175	56	4	21	Well reconditioned
			1,590	117	4	14	
			1,740	160	4	11	
	2008	City telemetry	1,400	120	12	12	
6	1978	Driller's Log	2,500	40	17	63	
	2011	Driller's Log	2,000	60	12	33	abandon lower borehole, pull screen assembly
	2015	City telemetry	2,500	70	12	36	
7	1998	Driller's Log	950	245	4	3.9	
			1,200	290	4	4.1	
	2008	City telemetry	1,000	380	4	2.6	
	2015	City telemetry	700	360	4	1.9	
8	2002	Driller's Log	923	200	24	4.6	
	2008	City telemetry	780	200	24	3.9	
	2015	City telemetry	500	160	24	3.1	
9	2014	Driller's Log	1,480	175	24	8.5	

Notes:
DTW - depth to water

Table 4 - Water Rights Summary

150143 - City of Othello, Washington

Water Right	Ecology File Number	Permit/Certificate	Authorized Wells	Qi (gpm)	Qa (afy)	Primary Qa (afy)	Development Schedule, Put to Full Use by:
182-D	CG3-*00150S	Certificate	Wells 2 through 8, proposed Well 10 [1]	200	34	34	June 1, 2007
183-D	CG3-*00150S	Certificate	Wells 2 through 8, proposed Well 10 [1]	200	148	148	June 1, 2007
3390-A	CG3-*05002C	Certificate	Wells 2 through 8, proposed Well 10 [1]	1,130	624	624	June 1, 2007
5338-A	CG3-*07076C	Certificate	Wells 2 through 8, proposed Well 10 [1]	900	1,440	1,440	June 1, 2007
G3-20368P	G3-20368P	Permit	Wells 2 through 8, proposed Well 10 [1]	2,000	3,024	778	June 1, 2007
G3-25032P	G3-25032P	Permit	Wells 2 through 8, proposed Well 10 [1]	2,250	3,000	2,600	June 1, 2007
G3-25033P	G3-25033P	Permit	Wells 2 through 8, proposed Well 10 [1]	870	2,500	1,476	June 1, 2007
G3-25933P	G3-25933P	Permit	Wells 2 through 9, proposed Well 10	2,000	3,000	0	November 1, 2020
			Totals:	9,550		7,100	

Notes:

[1] A proposed Well 9 was authorized as an additional point of withdrawal for all water rights; however, the actual location where Well 9 was constructed is only authorized under G3-25933P

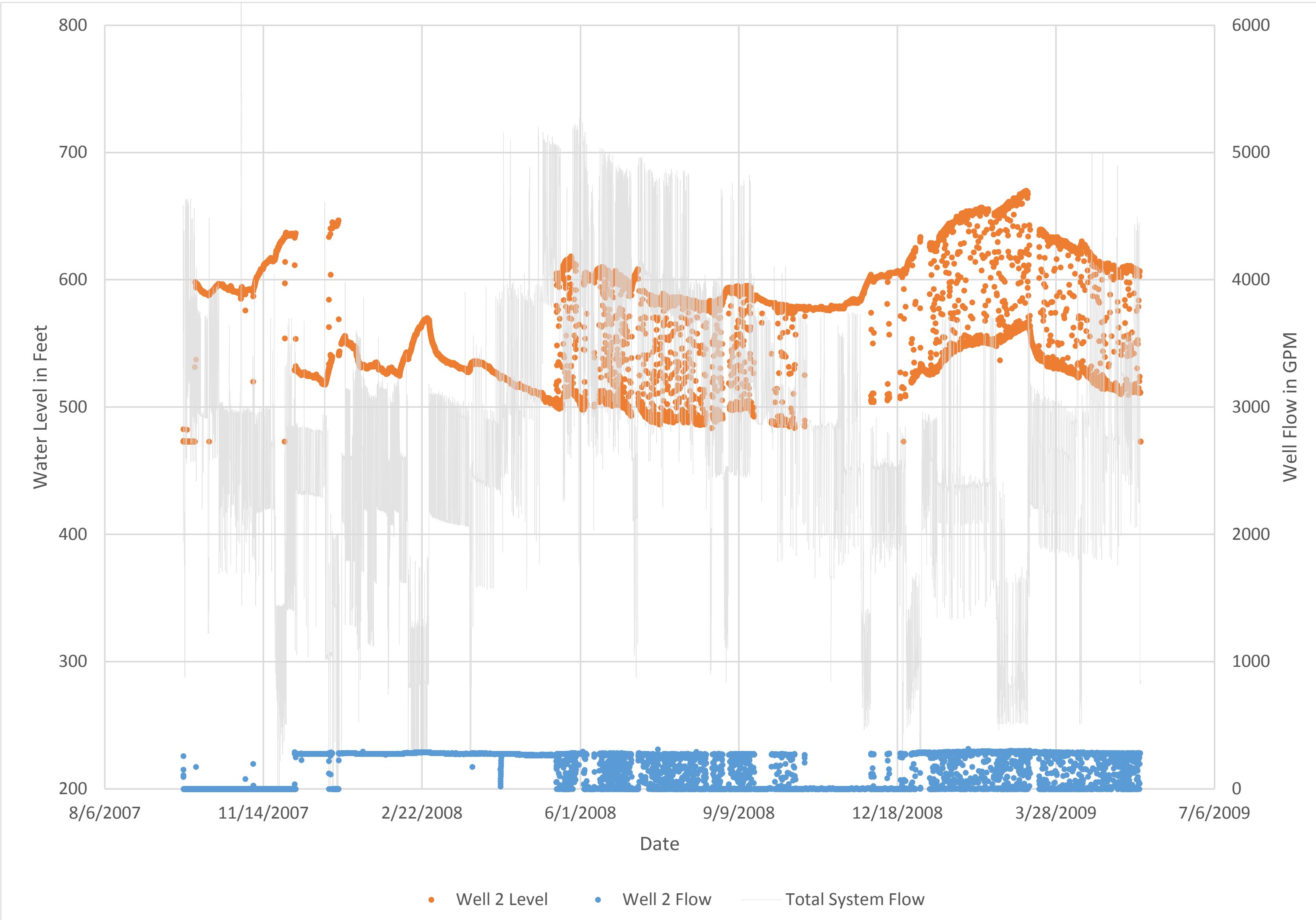
Qi - Instantons Quantity

Qa - Annual Quantity

gpm - gallons per minute

afy - acre-feet per year

FIGURES



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V:\150143 City of Othello Water Supply Planning\Deliverables\Well Assessment Memo\Figures

Figure 1
Well 2 Production and Water Levels, 2008
City of Othello Water Supply Well Assessment
Othello, WA

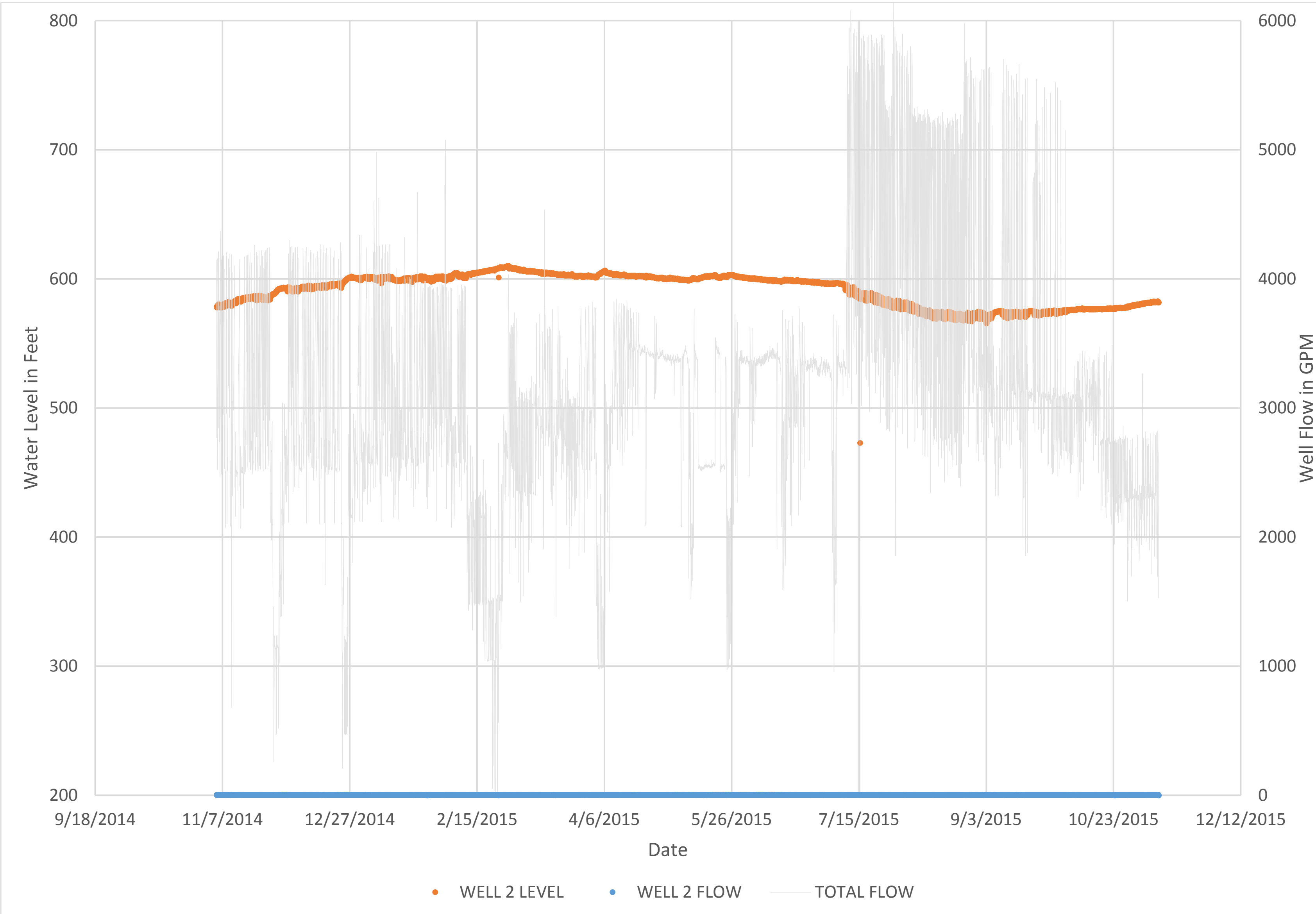

Figure 2

Well 2 Production and Water Levels, 2015

City of Othello Water Supply Well Assessment

Othello, WA

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2/12/2016

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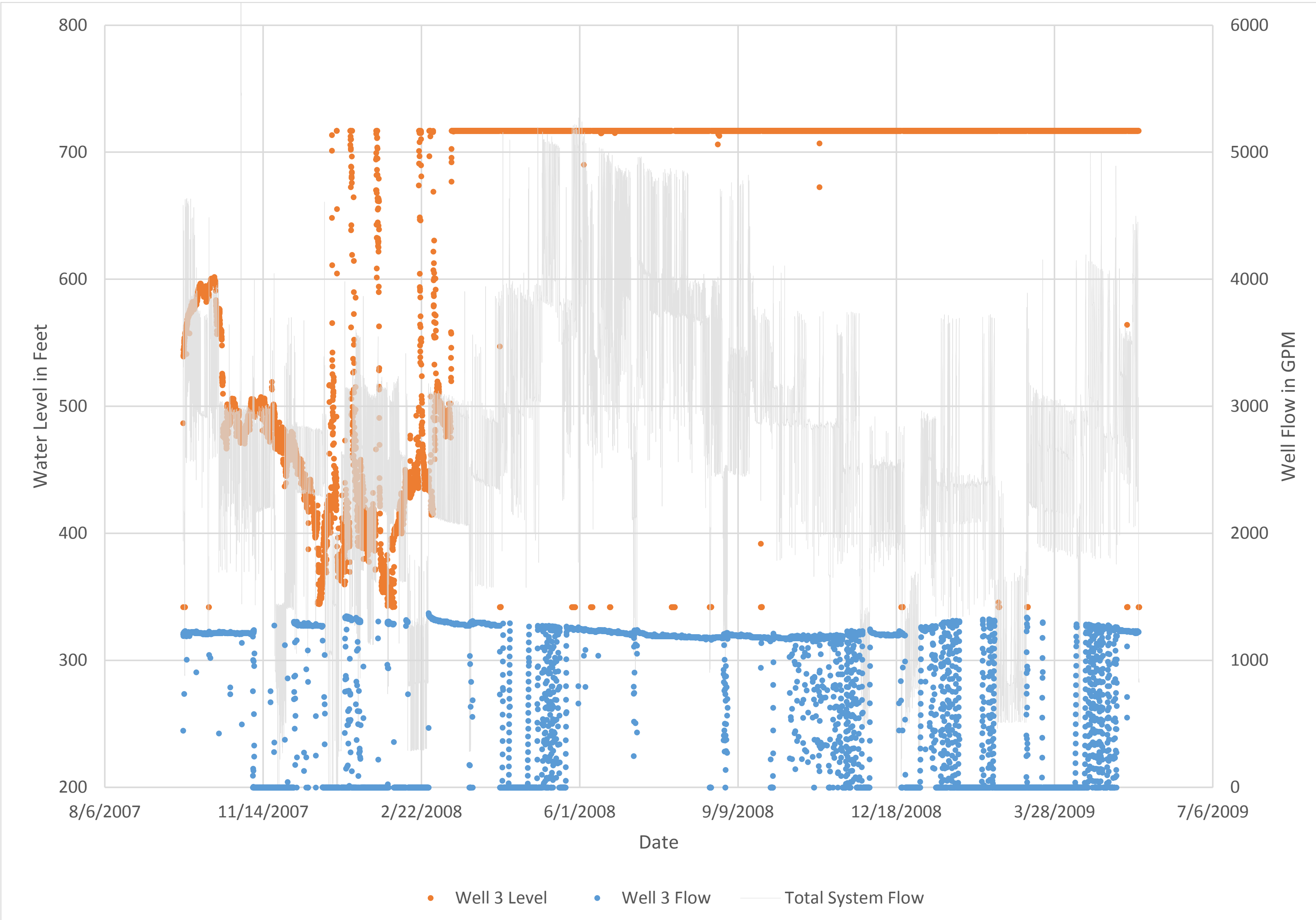

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2/12/2016
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Figure 3
Well 3 Production and Water Levels, 2008
City of Othello Water Supply Well Assessment
Othello, WA

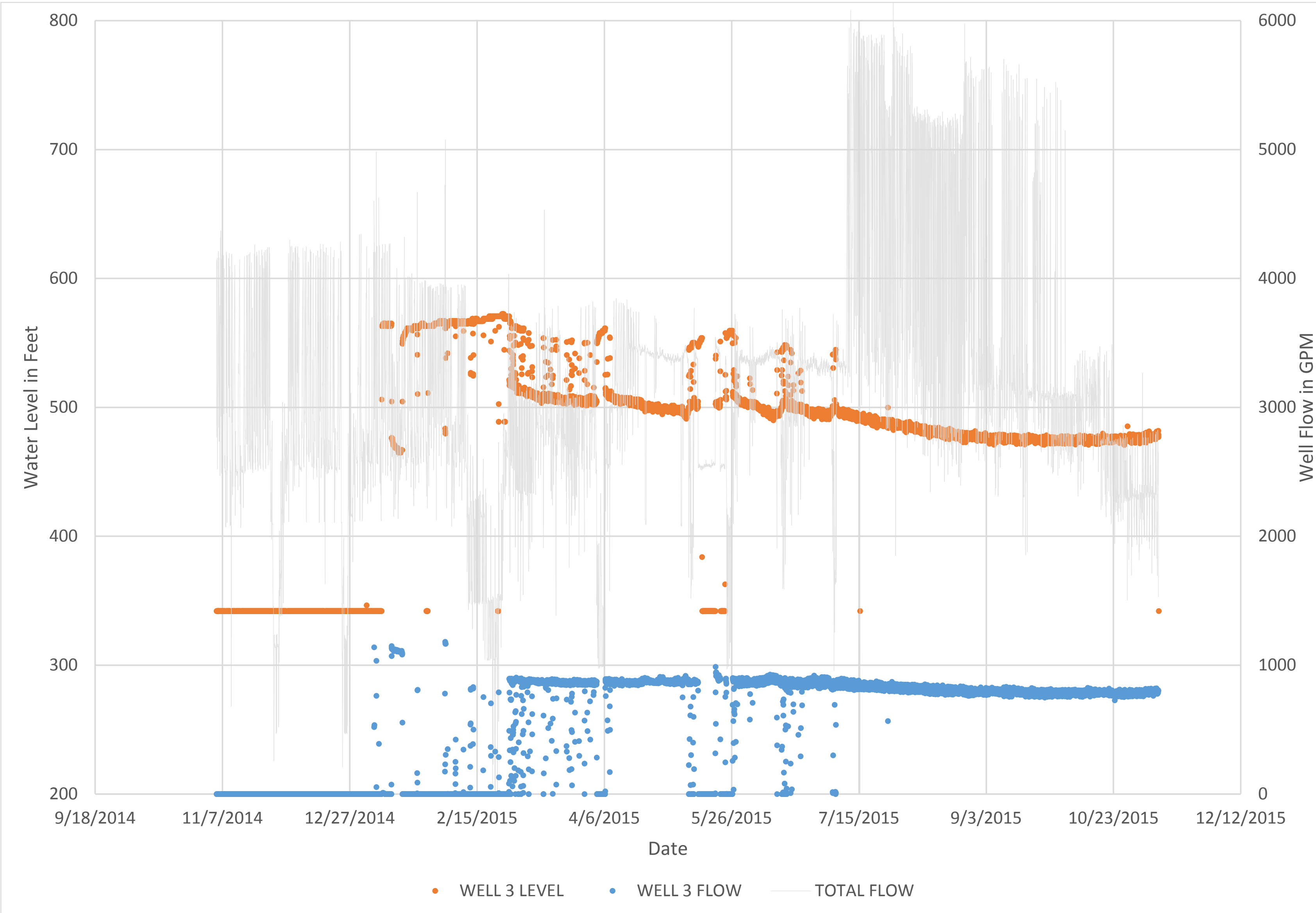

Figure 4
Well 3 Production and Water Levels, 2015

City of Othello Water Supply Well Assessment
Othello, WA

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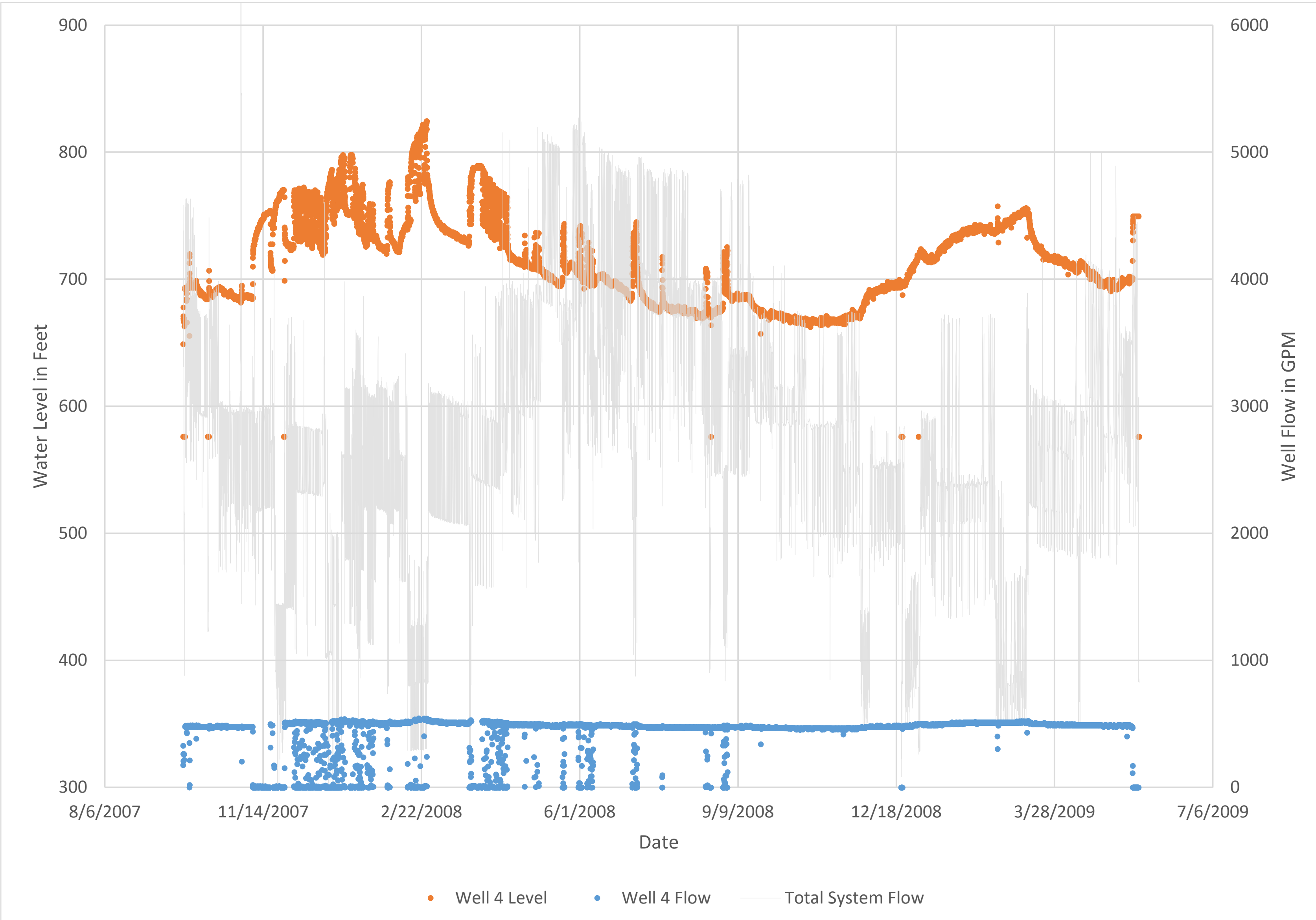

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Figure 5
Well 4 Production and Water Levels, 2008

City of Othello Water Supply Well Assessment
Othello, WA

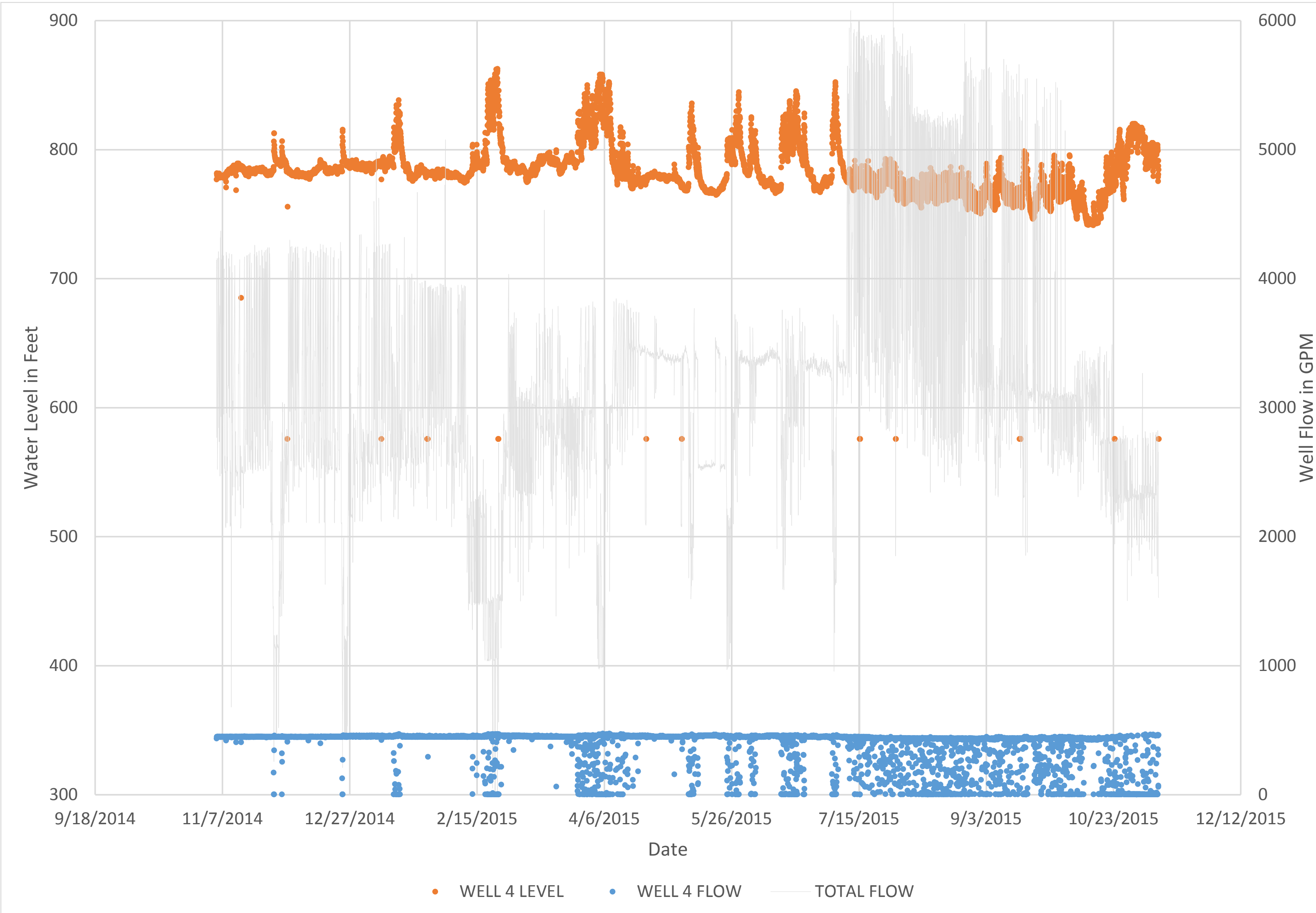

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Figure 6
Well 4 Production and Water Levels, 2015
City of Othello Water Supply Well Assessment
Othello, WA

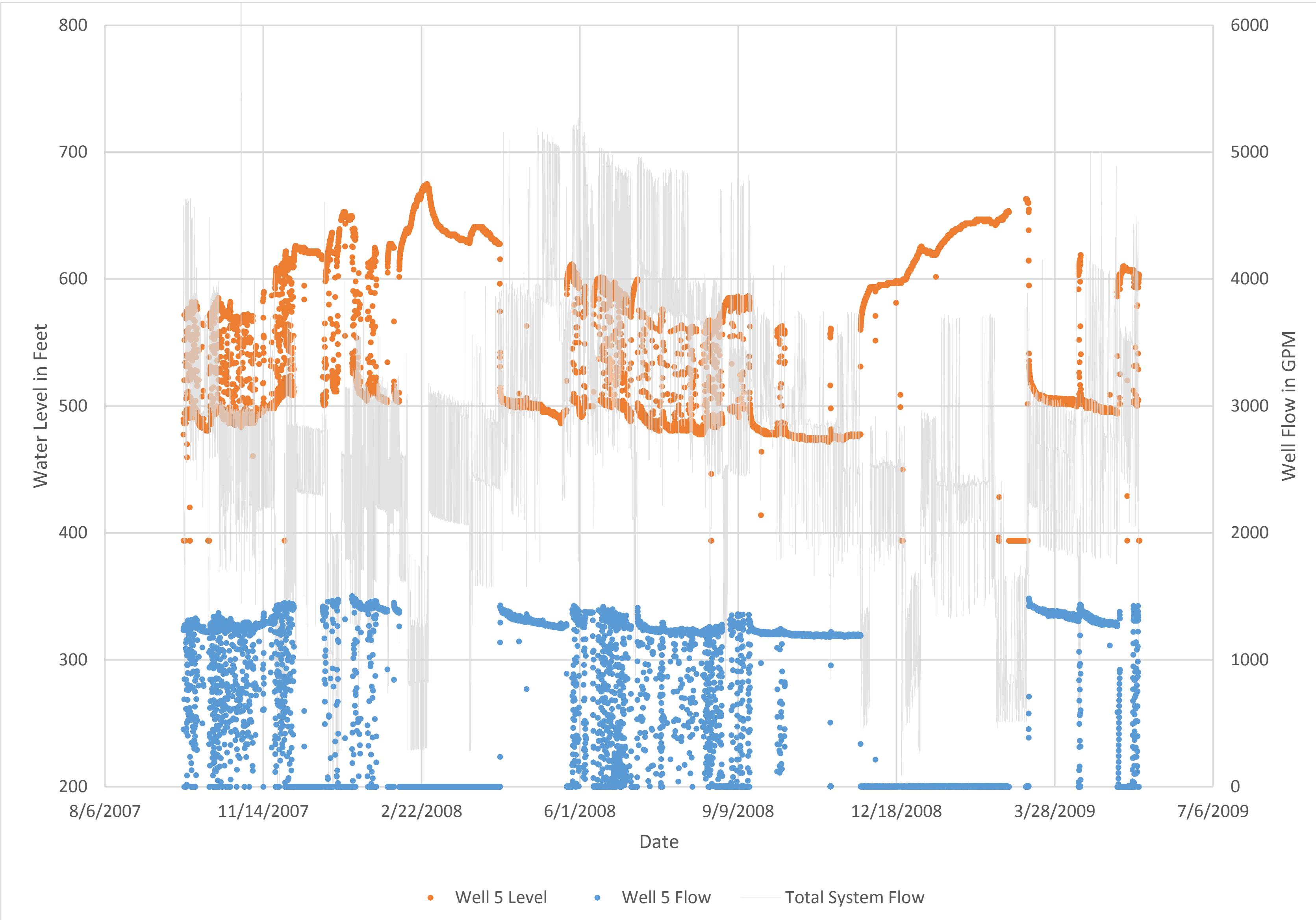

Figure 7
Well 5 Production and Water Levels, 2008
City of Othello Water Supply Well Assessment
Othello, WA

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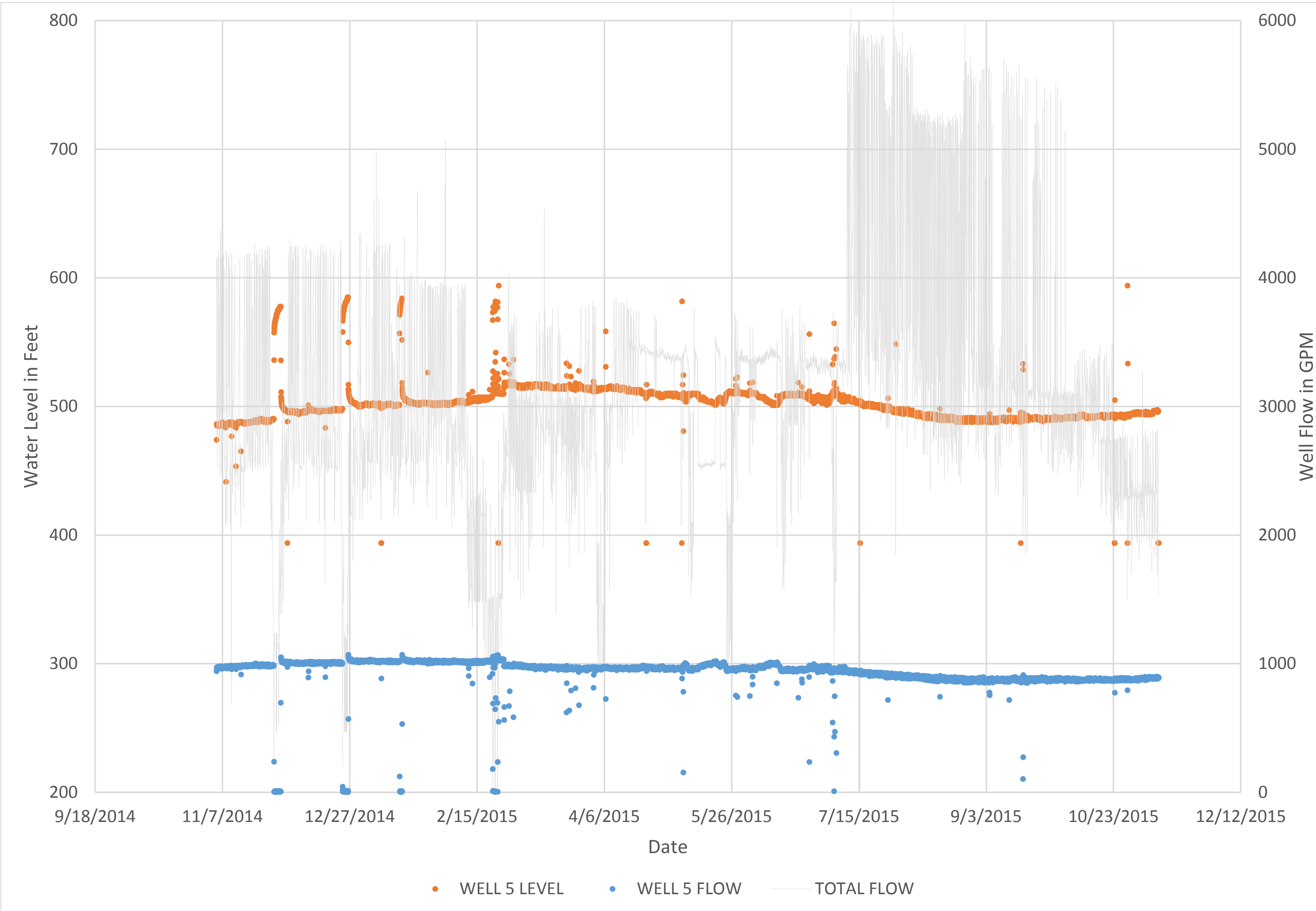

Figure 8
Well 5 Production and Water Levels, 2015
City of Othello Water Supply Well Assessment
Othello, WA

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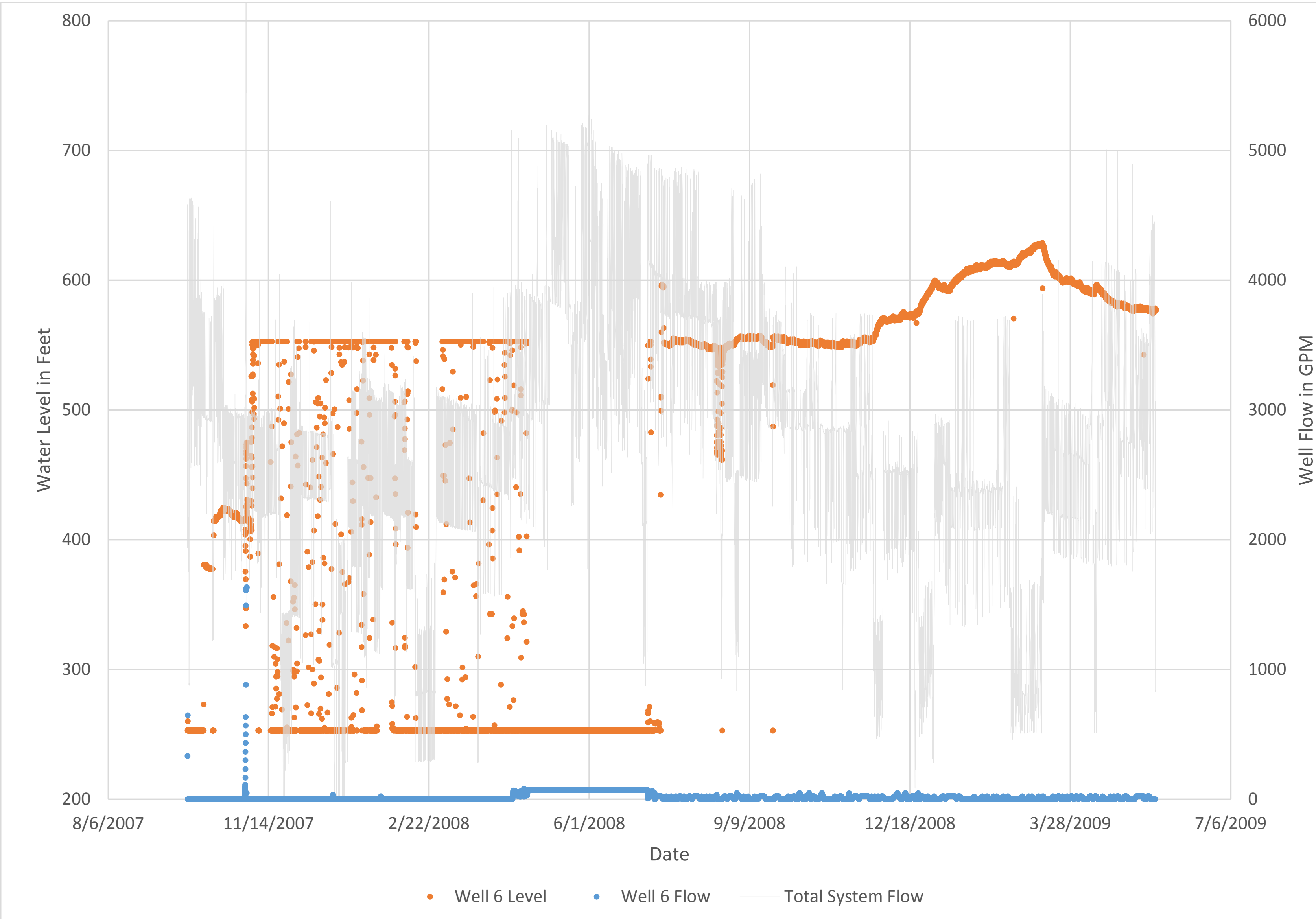

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Figure 9
Well 6 Production and Water Levels, 2008
City of Othello Water Supply Well Assessment
Othello, WA

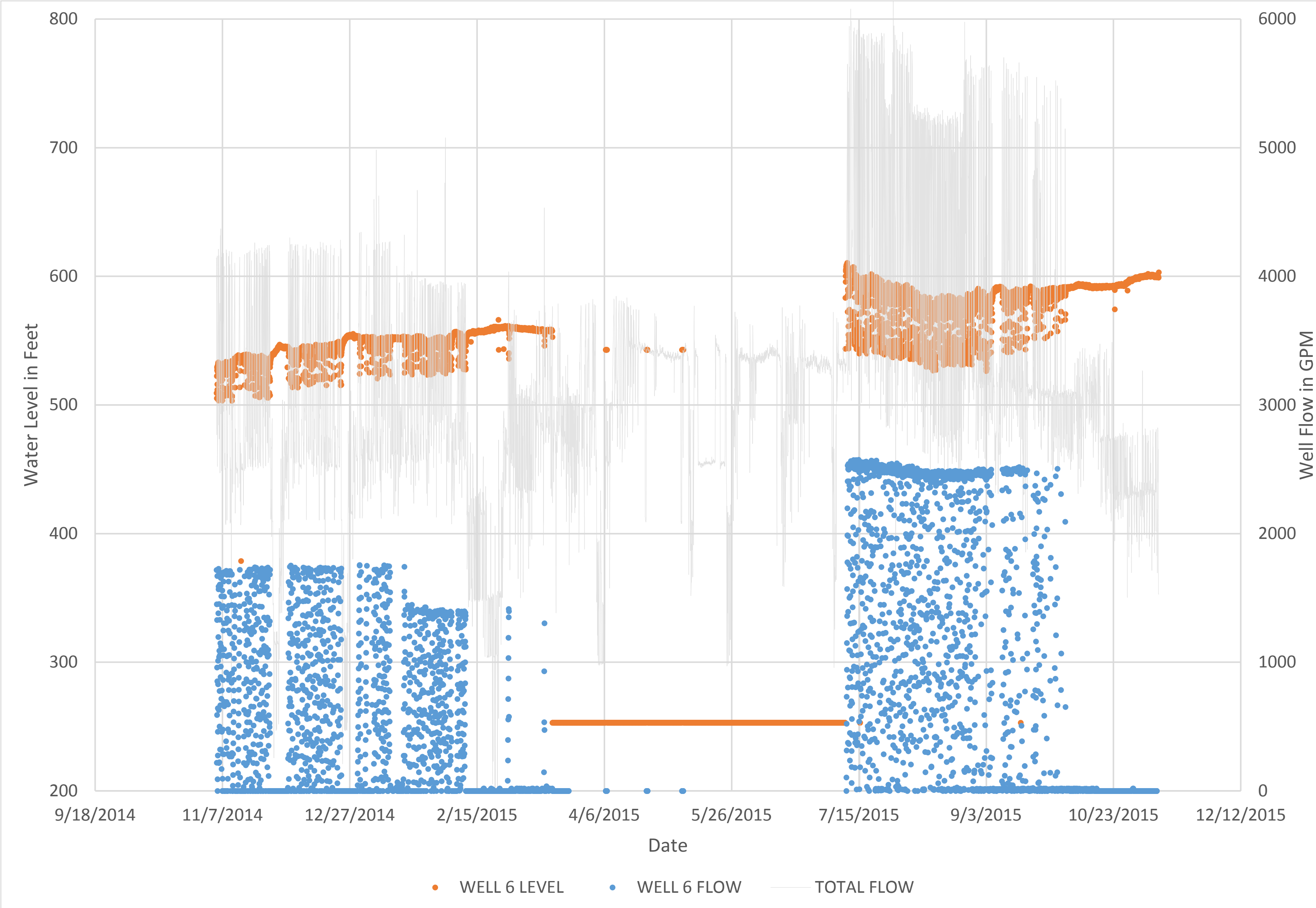

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Figure 10
Well 6 Production and Water Levels, 2015

City of Othello Water Supply Well Assessment
Othello, WA

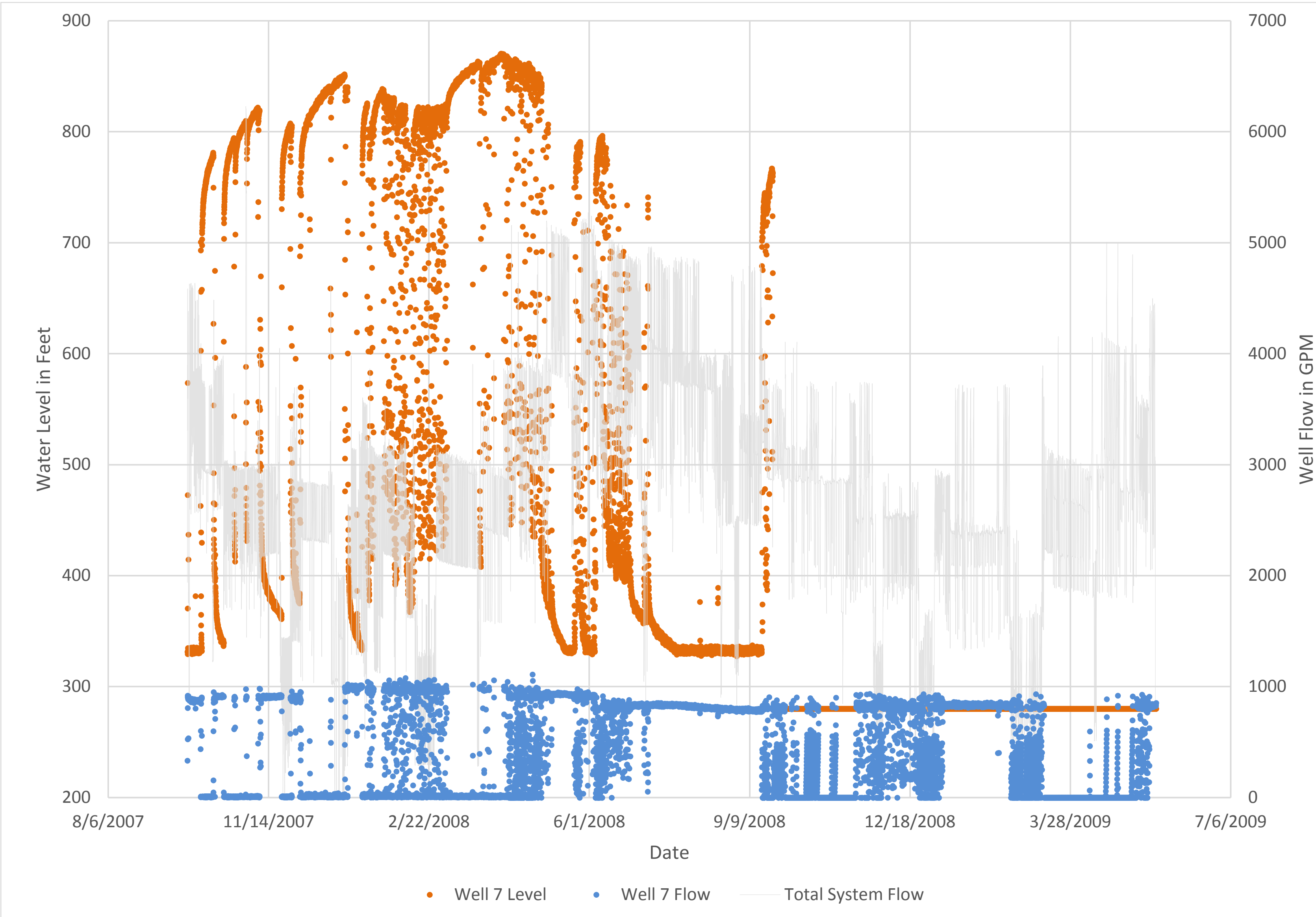

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Figure 11
Well 7 Production and Water Levels, 2008
City of Othello Water Supply Well Assessment
Othello, WA

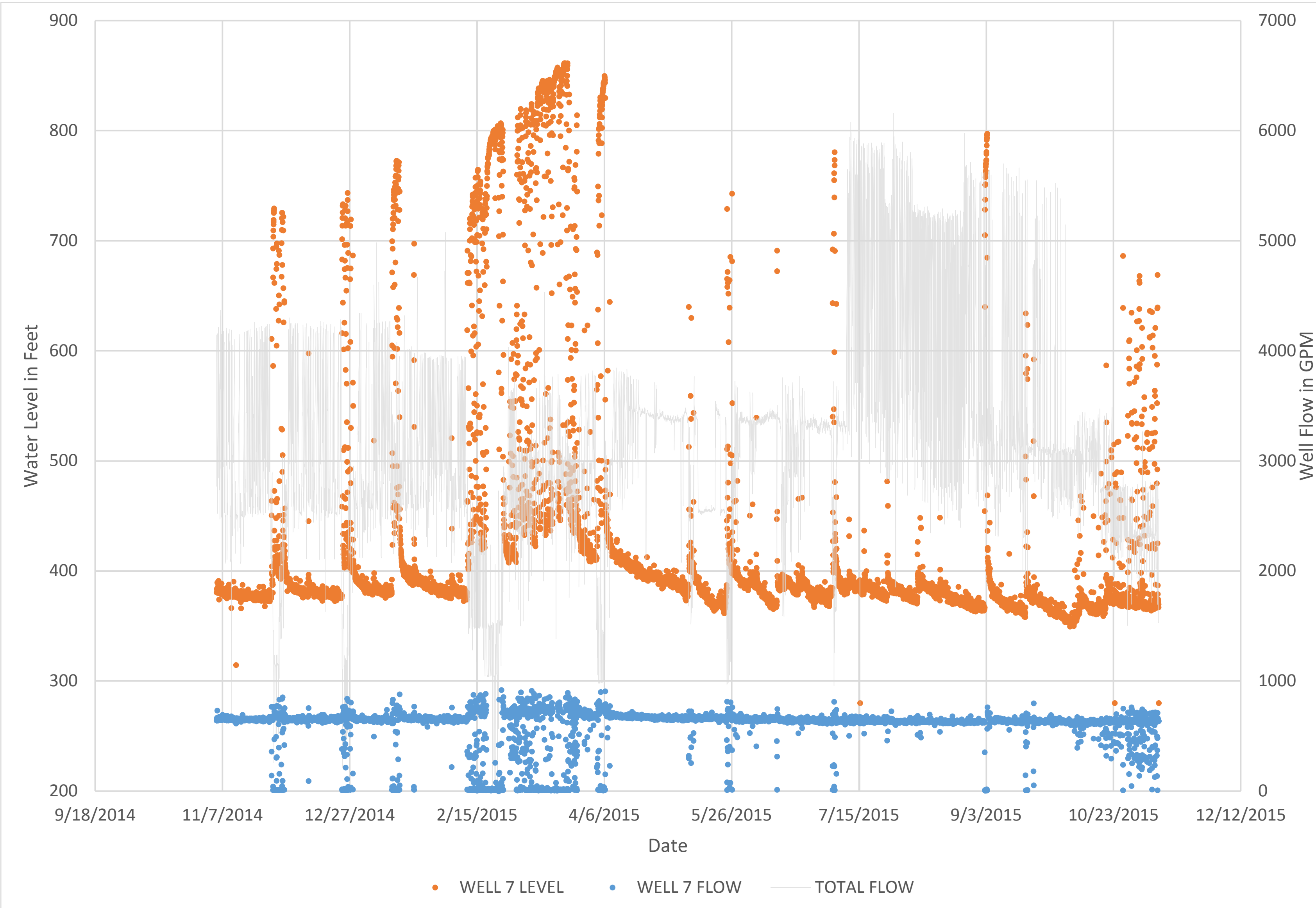

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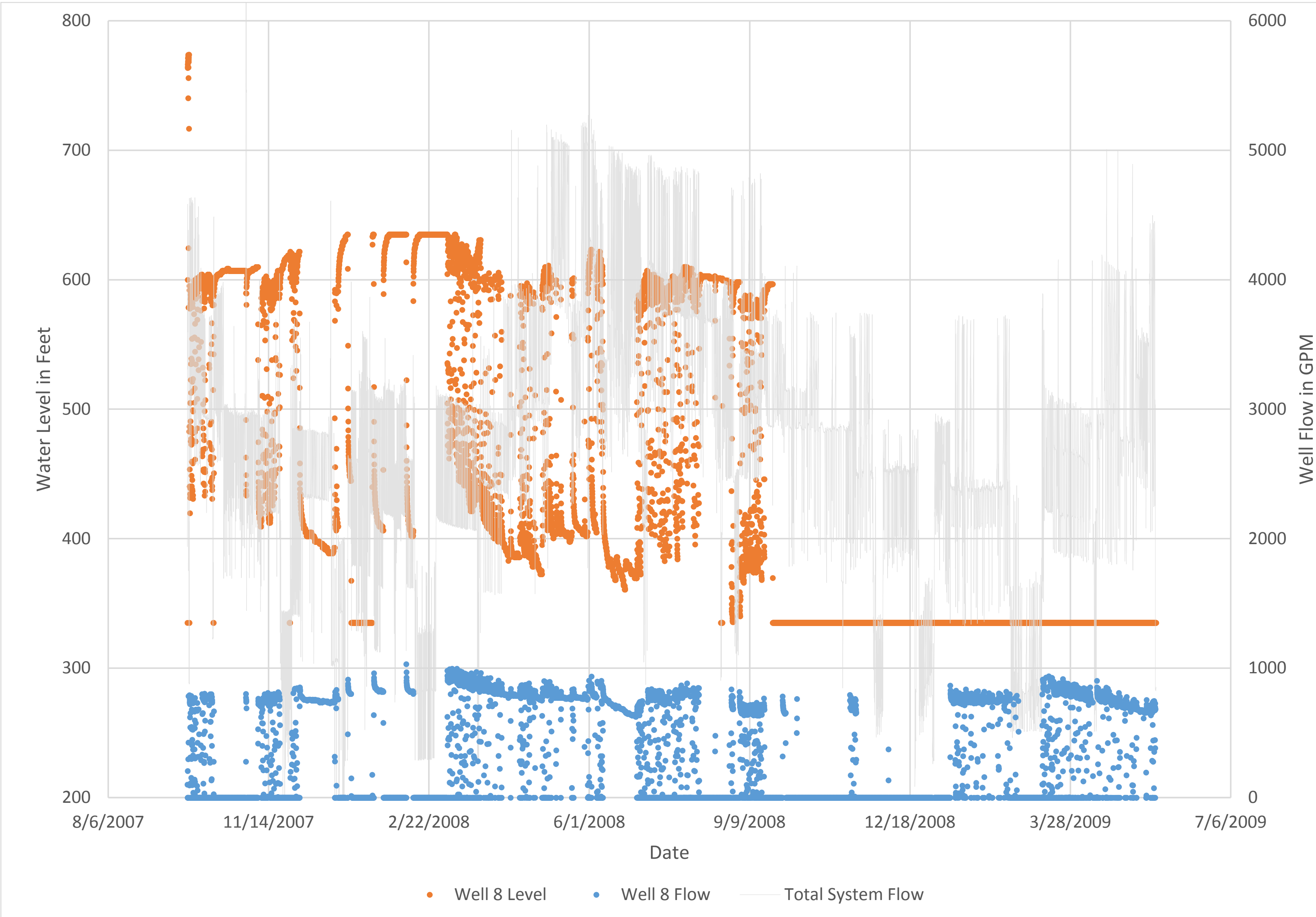
Figure 12
Well 7 Production and Water Levels, 2015

City of Othello Water Supply Well Assessment
Othello, WA



Aspect Consulting
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Figure 13
Well 8 Production and Water Levels, 2008

City of Othello Water Supply Well Assessment
Othello, WA

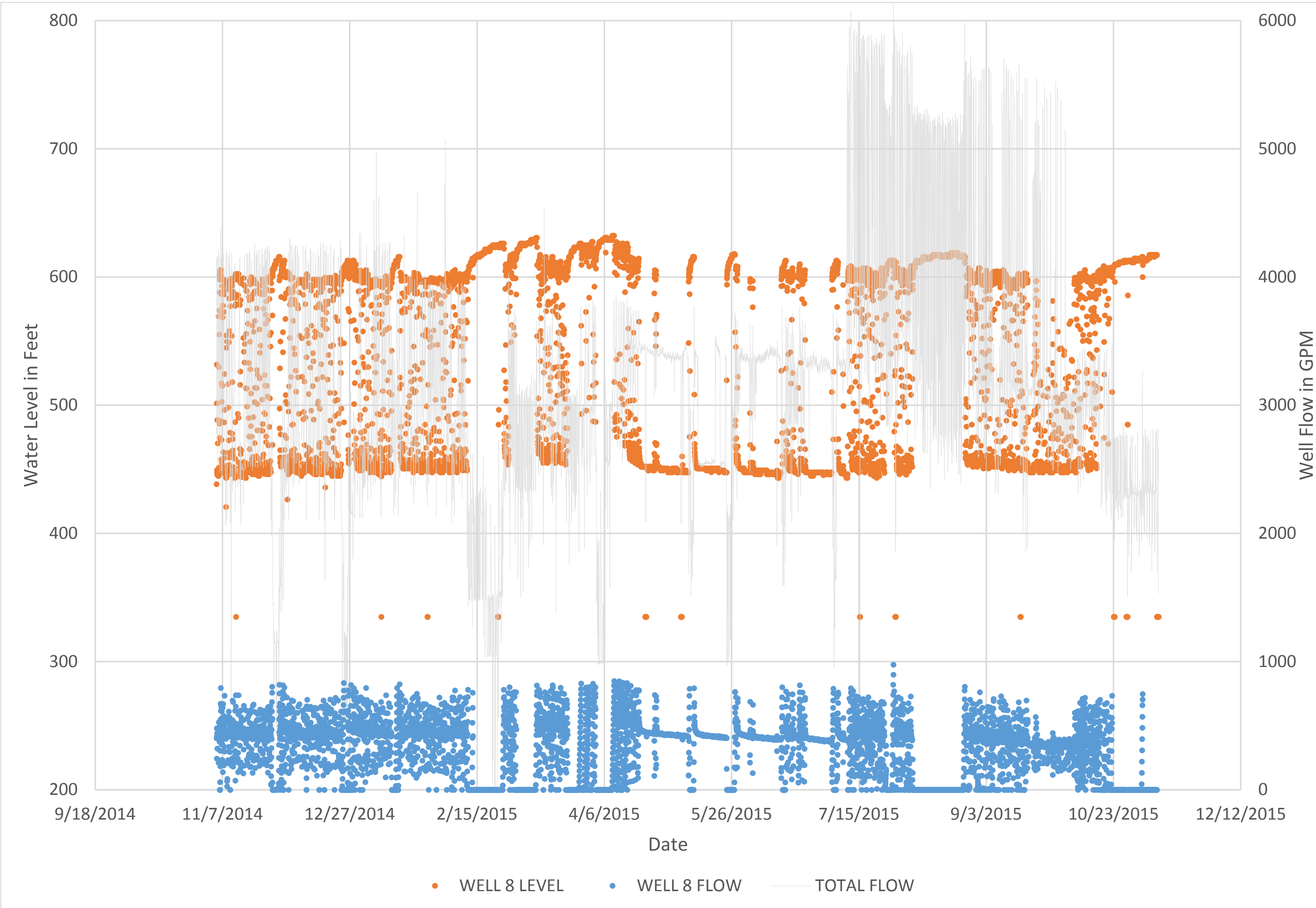

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Figure 14
Well 8 Production and Water Levels, 2015
City of Othello Water Supply Well Assessment
Othello, WA

ATTACHMENT A

Driller's Well Logs

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. G3-25033
Permit No. G3-25033P

(1) OWNER: Name City of Othello Address 512 East Main, Othello WA 99344

(2) LOCATION OF WELL: County Adams NW 1/4 SE ¼ SE ¼ Sec 34 T 16 N., R 29E W.M.
Bearing and distance from section or subdivision corner 1250 N – 1050' W of SE Cor 34

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #3
New well ☐ Deepened ☐ Reconditioned ☒*
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ...... inches.
Drilled ...... ft. Depth of completed well ...... ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ......" Diam. from ...... ft. to ...... ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☐ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☐
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☐ No ☐ To what depth? ...... ft.
Material used in seal ......
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name Jacuzzi
Type: vertical turbine H.P. 450

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 1115 ft.
Static level 385 ft. below top of well Date 5/11/77
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? **
Yield: 1714 gal./min. with 100 ft. drawdown after 2 hrs.
" 1463 " 76 " 2 "
" 1263 " 58 " 2 "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	443'	30"	388'	90"	386'
10"	389'	45"	387'	105"	386'
20"	389'	60"	387'	120"	385'

Date of test May 11, 1977
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Does not apply --		
no modifications were made		
to the original bore hole.		

O pad
870
250
Man

Work started ......, 19...... Completed ......, 19......

ENGINEER'S STATEMENT:
New pumping equipment for this well was installed under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME BROWN AND CALDWELL (Person, firm, or corporation) (Type or print)
Address 100 W. Harrison, Seattle, WA 98119

[Signed] [signature] (Engineer)

License No. 12931 Date June 8, 1977

*New pump and pump control equipment added. No modifications were made to the bore hole.
**Brown and Caldwell consulting engineers.

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. ______

(1) OWNER: Name City of Othello Address 512 E. Main Street Othello, WA 99344

(2) LOCATION OF WELL: County Adams Well #4 ___ ¼ ___ ¼ Sec. 3 T. 15 N., R. 29 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4

Abandoned ☐ New well ☐ Deepened ☒ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 9 7/8 inches.
Drilled ~~1450~~552 feet. Depth of completed well 1450 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: n/a " Diam. from ___ ft. to ___ ft.
Welded ☐ ___ " Diam. from ___ ft. to ___ ft.
Liner installed ☐
Threaded ☐ ___ " Diam. from ___ ft. to ___ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ___ Slot size ___ from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☒ No ☐ To what depth? ___ ft.
Material used in seal Done Previously
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ___ Depth of strata ___
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level ___ ft. below top of well Date ___
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ___
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Hard grey basalt 175 PSI	898	930
Medium grey - broken seams	930	935
Broken & pourous 250 PSI	935	XXX 945
Medium grey - broken seams	945	970
Hard grey basalt	970	986
Pourous basalt	986	1004
XXXXXXXXXXXXXXXXXX		
Broken basalt - pourous seams	1004	1023
Medium grey	1023	1047
Hard grey	1047	1067
Black pourous PSI 260	1067	1073
Broken basalt	1073	1080
Medium grey - broken seams	1080	1120
Hard grey basalt	1120	1161
Soft black basalt	1161	1170
Medium black basalt	1170	1242
Red pourous 320 PSI	1242	1246
Soft black basalt	1246	1260
Medium basalt - broken seams	1260	1377
Soft black basalt	1377	1396
Hard grey - broken seams 340 PSI	1396	1450
Drilled 9 7/8" hole		

RECEIVED FEB 11 1992 DEPARTMENT OF ECOLOGY

Work started 12/16-91, 19__ Completed 1-5-92, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME BJ Exploration Co., INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address Rt 4 Box 4517 Kennewick, WA 99337

(Signed) [signature] (WELL DRILLER) License No. 0337

Contractor's Registration No. BJEXPC1I32QK Date 2/4/92, 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. ______

(1) OWNER: Name City of Othello Address 512 E Main

(2) LOCATION OF WELL: County Adams County ___ ¼ SE ¼ Sec. 3 T. 15 N., R. 29 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) West side 15th Avenue

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ______ inches.
Drilled ______ feet. Depth of completed well ______ ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 15 " Diam. from 0 ft. to 150 ft.
Welded ☐ 12 " Diam. from 150 ft. to 421 ft.
Liner installed ☐
Threaded ☐ 10 " Diam. from 421 ft. to 817 ft.

Perforations: Yes ☐ No ☐
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☐ No ☐ To what depth? ______ ft.
Material used in seal ______
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level ______ ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Pulled 10" casing from		
421 feet to 817 feet.		

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MAR 18 1992
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started ______, 19__. Completed ______, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Ken Thompson Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2096 Hamilton Rd
(Signed) Ken Thompson (WELL DRILLER) License No. 0648
Contractor's Registration No. KENTHDI133QB Date 3-10, 1992

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) **OWNER:** Name City of Othello Address 512 E. Main Street, Othello, WA 99344

(2) **LOCATION OF WELL:** County Adams — SE ¼ SW ¼ Sec 3 T 15 N., R 29E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 5
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☒ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 20/16/12 inches.
Drilled not changed Depth of completed well 963 ft.

(6) **CONSTRUCTION DETAILS:** Not Changed
Casing installed: 20" Diam. from +1 ft. to > 361 ft.
Threaded ☐ 16" Diam. from 361 ft. to > 635 ft.
Welded ☒ 12" Diam. from 635 ft. to > 710 ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations 3/8 in. by 2.5 in.
~ 650 perforations from 550 ft. to 634 ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☐ Not Changed
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☐ Not Changed Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☐ No ☐ Not Changed To what depth? .... ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) **PUMP:** Manufacturer's Name Layne & Bowler
Type: Vertical lineshaft turbine H.P. 350

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 1055 ft.
Static level 277 ft. below top of well Date 3/31/87
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? SEI
Yield: 1175 gal./min. with 56 ft. drawdown after 4 hrs.
" 1590 " 117 " 8 "
" 1740 " 160 " 16 "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
5	309	60	301	485	290
15	306	125	298	965	288
30	304	185	296	1715	285

Date of test 3/31-4/1/87
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Existing well was drilled by Charles Jungman and completed 4/9/74 per previous WaterWell Report.		
Work done to well at this time consisted basically of bailing from 952', chemical treatments, mechanical agitation, reperforating, sonar jetting, pump installation and testing.		

RECEIVED
APR 20 1987
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 11/11 1986 Completed 4/2 1987

WELL DRILLER'S STATEMENT:

This well was ~~drilled~~ reconditioned under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Schneider Equipment, Inc. (Person, firm, or corporation) (Type or print)
Address 21881 River Road NE, St. Paul, OR 97137

[Signed] Stephen J Schneider (Well Driller)

License No. 643 Date 4/6 1987

SEI #8706

4/20/87

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 320368
Permit No. 320368

(1) **OWNER:** Name CITY OF OTHELLO Address OTHELLO WASH.

(2) **LOCATION OF WELL:** County ADAMS SE¼ SE¼ SW¼ Sec. 3 T. 15 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 30"x24"x16"x12 inches.
Drilled 1007 ft. Depth of completed well 1007 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 30" Diam. from +1 ft. to 192 ft.
Threaded ☐ 20" Diam. from +1 ft. to 342 ft.
Welded ☒ 16" Diam. from ft. to 666 ft.

Perforations: Yes ☐ 12 No ☒
Type of perforator used STAR
SIZE of perforations 4 + 6 in. by in.
400 perforations from 550 ft. to 650 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 342 ft.
Material used in seal CEMENT - CASING
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 1050 ft.
Static level 283 ft. below top of well Date 12-19-73
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? [illegible]
Yield: 1575 gal./min. with 148 ft. drawdown after 12 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1 min	307				
3 --	288				
COMPLETE	4 HRS				

Date of test 12-19-73
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 64 Was a chemical analysis made? Yes ☒ No ☐

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SOIL	0	3
BROWN CLAY	3	65
GREY CLAY	65	160
BLUE CLAY	160	192
BLACK BASALT	192	205
GREY BASALT	205	235
BLACK BASALT	235	294
GREY BASALT	294	335
BROWN BASALT	335	365
BLACK BASALT	365	385
BROWN BASALT	385	397
BLACK BASALT	397	488
GREY BASALT	488	519
BLACK BASALT	519	895
GREY BASALT	895	917
BLACK BASALT	917	960
GREY BASALT	960	975
BLACK BASALT	975	1007

Coded
RECEIVED
APR 12 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE
20004
302024
Mun

Work started 9-1, 1973. Completed 4-9, 1974.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CHAS. JUNGMANN DRILLING CO.
(Person, firm, or corporation) (Type or print)

Address 115 REES AVE W.W. WASH

[Signed] Charles Jungmann
(Well Driller)

License No. 0229 Date 4-9, 1974

4/15/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. G3-25032P

(1) OWNER: Name City of Othello Address City Hall, Othello, Washington

(2) LOCATION OF WELL: County Adams County NE ¼ NE ¼ Sec 4 T 15 N., R 29 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 6
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 20" & 17-1/2" inches.
Drilled 1210 ft. Depth of completed well 1210 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 24 " Diam. from 0 ft. to 52 ft.
Threaded ☐ 20 " Diam. from 0 ft. to 212 ft.
Welded ☒ 16 " Diam. from 997 ft. to 1208 ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Layne
Type St.Steel shaped wire Model No.
Diam. 16 Slot size .250 from 1015 ft. to 1035 ft.
Diam. 16 Slot size .250 from 1055 ft. to 1075 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 52 ft.
Material used in seal cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Layne
Type: Diesel H.P. 700

(8) WATER LEVELS: Land-surface elevation above mean sea level 1053 ft.
Static level 197 ft. below top of well Date 1/25/78
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne

Yield: gal./min.	with ft. drawdown	after hrs.
2500	14:18	10min.
2500	25.4	100min
2500	40.45	1000min

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
min	232.84	100min	221.12	300min	216.66
10 min	231.05	150min	218.73	600min	212.75
60 min	224.08	200min	218.00	720min	212.04

Date of test 1/26/78
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Gravel and boulders	0	30'
Gravel and boulders	30	52
Clay and sand	52	158
Clay and sand(streaks of basalt	158	214
Black Basalt Hard	214	211
Black Basalt Hard	211	230
Black Basalt Hard	230	235
Black & Red basalt	235	246
Black Basalt Hard	246	274
Fractured Basalt Black	274	343
Brown Clay	343	360
Black & Gray Basalt	360	440
Black & Gray Basalt	440	508
Black Basalt Hard	508	563
Black Basalt Hard	563	624
Black Basalt Hard	624	703
Conglomerated Black Basalt	703	717
Black Basalt	717	878
Black & Gray Basalt	878	965
Black Basalt Hard	956	1011
Black Gray & Red Basalt	1011	1055
Black Gray & Green Basalt	1055	1068
Black & Gray Basalt	1068	1098
Black Basalt Hard	1098	1106
Black & Brown Basalt Hard	1106	1120
Black Basalt Green spots	1120	1210

2250 Min
300 Min

Work started October 1, 1977. Completed February 10, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME E. E. Luhdorff Co. - A Division of Layne-Western Co., Inc. (Person, firm, or corporation) (Type or print)

Address P.O. Box 336, Moses Lake, WA 98837

[Signed] William A. Gustavson (Well Driller)

License No. 0733 Date Feb. 14, 1978

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

JUL [illegible] 1997

Start Card No. 34672
UNIQUE WELL I.D. # AAP 645
Water Right Permit No. 63-29644

OWNER: Name City of Othello Address 512 E Main, Othello, WA 99344

(2) LOCATION OF WELL: County Adams SE 1/4 SE 1/4 Sec 9 T 15N N., R 29E WM

(2a) STREET ADDRESS OF WELL (or nearest address) 1400 LF N of City Limits

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 20" ~~16~~ inches.
Drilled 820 feet. Depth of completed well 820 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 20" Diam. from 0 ft. to 386 ft.
Welded ☒ 16" Diam. from 373 ft. to 670 ft.
Liner installed ☐ 16" Diam. from 740 ft. to 795 ft.
Threaded ☐ 16 815 820

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name NAGAOKA
Type 304 Stainless Model No. ______
Diam. 16 Slot size .050 from 670 ft. to 740 ft.
Diam. 16 Slot size .050 from 795 ft. to 815 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 386 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 125 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by N/A (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne
Yield: 1500 gal./min. with 362 ft. drawdown after 24 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test May 13 1997
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 1700 gal./min. with stem set at 800 ft. for 4 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Unconsolidated Sediments	0	280
Clay w/Pieces of Black Basalt	280	300
Black Basalt Hard	300	420
Frac Black Basalt	420	450
Black Basalt Hard	450	490
Fractures	490	520
Black Basalt Hard	520	600
Fractures	600	610
Black Basalt Hard	610	680
Red vesicular Basalt Soft	680	730
Black Basalt Hard	730	800
Black & Red basalt frac Soft	800	810
Black Basalt Hard	810	820

RECEIVED
JUL [illegible] 1997

Work Started 12-6-96, 19. Completed 4-17, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Staco Well Services Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 220 Academy St Mt Angel O[illegible]
(Signed) [signature] (WELL DRILLER) License No. 1790
Contractor's Registration No. STACOWS131OH Date 6-30-97, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

MAR 13 2000

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 34672
UNIQUE WELL I.D. # AAP 562
Water Right Permit No.

(1) OWNER: Name City of Othello Address 512 E. Main Othello, WA 99344

(2) LOCATION OF WELL: County Adams County - SE 1/4 SE 1/4 Sec 9 T. 15N N., R 29E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 1400 LF N. of City Limits

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #7
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16" inches.
Drilled 820 feet. Depth of completed well 820 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 20" Diam. from 0 ft. to 386 ft.
Welded ☒ 16" Diam. from 380 ft. to 670 ft.
Liner installed ☐
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name NAGAOKA
Type V Wire Model No.
Diam. 16 Slot size .050 from 670 ft. to 740 ft.
Diam. Slot size from 795 ft. to 815 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 200 ft.
Material used in seal Neat Cement 13 Yds
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 125 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Schnieder Equip
Yield: 950 gal./min. with 245 ft. drawdown after 4 hrs.
" 1200 " 290 " 4 "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 1000 gal./min. with stem set at 800 ft. for 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Soil & Fill Material	0	4
Sediments, Brown - Gray	4	280
Clay, Some Black Basalt	280	300*
Basalt Black Hard	300	420
Basalt Fract Hard Black	420	450
Basalt Hard Black	450	490
Basalt Fract Black	490	520
Basalt Hard Black	520	600
Basalt Fract Black	600	610
Basalt Hard Black	610	680
Basalt Red - Black Vesic	680	730
Basalt Hard Black	730	800
Basalt Med Soft Black - Red	800	810
Basalt Hard Black	810	820

RECEIVED
MAR 09 2000
DEPARTMENT OF ECOLOGY

Work Started 12-7-97, 19. Completed 5-30-98, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STACO Well Services, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 220 Academy Street Mt. Angle OR 97362
(Signed) (WELL DRILLER) License No. 0859
Contractor's Registration No. STACO WS 1310H Date 5-30, 19 98

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG Well #3 No. Appli. #5002
C 3392

Date February, 1957
Record by well driller
Source driller's record

Location: State of WASHINGTON
County Adams
Area
Map

NW¼SE¼ SE¼ sec 34 T. 16 N., R. 29 E.

Diagram of Section: 34

Drilling Co. Gray & Osborne
Address Yakima, Washington
Method of Drilling .... Date ...., 19....
Owner City of Othello, Wash.
Address
Land surface, datum .... ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	See drawing in file		
	PUMP TEST:		
	Dim. 900'x16"		
	SWL: 278 ft.		
	DD: 36 ft.		
	~~Yield: 1340 g.p.m.~~		
	~~Water Tem.p 75° F.~~		
	~~Type & size of pump: Turbine 1130 g.p~~		
	~~" " " " motor: elec. 150 h.p.~~		
	CASING:		
	16" diam. std. wt. from 0 to 197ft.		
	Meter 104612		

Turn up Sheet .... of .... sheets

No......../........-........

WELL LOG.—Continued

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward	——	
	Sandy loam	5	5
	Gravel	8	13
	Hardpan	7	20
	Silty sand	3	23
	Partly cemented gravel	7	30
	Loose gravel	2	32
	Gravel & clay	58	90
	Yellow clay	45	135
	Brown clay	5	140
	~~xxxxxx~~ Sand	10	150
	Gritty clay	15	165
	Brown clay	13	178
	Broken basalt	12	190
	Basalt	38	228
	Muddy broken basalt	5	233
	Broken basalt	17	250
	Basalt	61	311
	Brown shale & basalt	28	339
	Basalt	63	402
	Basalt crevices	5	407
	Basalt	161	561
	Shale & basalt	15	576
	Basalt	1	577
	Broken basalt	30	607
	Basalt	153	760
	Broken basalt	10	770
	Basalt	130	900

Meter 11/18/76 280 475 ccc

Well Test: 5/11/77: SWL 385
1714 gpm, 100' DD, 2 hours
1463 76 2
1263 58 2
Recovery: Complete in 2 minutes

S. F. No. 74**—12-54—3M. 40108.

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT Appli. #7076

WELL LOG No. P16871 C 5383

Date February 3, 19 65
Record by Driller
Source Driller's Record

Location: State of WASHINGTON
County Adams
Area 136.5' S & 134' W of NE
Map corner of SE¼, Sec. 3
NE¼NE ¼ nese ¼ sec. 3 T. 15 N., R. 29 E.

3/31/34
3
33

Diagram of Section

Drilling Co. Charles Jungmann Drilling Company
Address 115 Rees Ave., Walla Walla, Washington
Method of Drilling Cable Date Jan. 30, 19 65
Owner City of Othello
Address Othello, Washington
Land surface, datum 1050 ft. above/below

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Municipal well		
	Sand, gravel, clay	0	128
	Broken basalt	128	155
	Black basalt	155	178
	Grey basalt	178	232
	Brown basalt	232	255
	Grey basalt	255	326
	Brown basalt	326	349
	Black, grey	349	562
	Broken black basalt	562	651
	Black basalt and broken	651	795
	Grey basalt	795	866
	Black basalt with seams	866	900
	Grey basalt	900	905

Turn up Sheet ...... of ...... sheets

WELL LOG.—Continued   No........../..........-..........

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward	———	
	Casing: 20" from +1 to 57.7'		
	16" from +1 to 167.3'		
	12" from 154.3' to 443'		
	10" from 432.11 to 826'		
	Perforated from 550 to 795'		
	Surface sealed with casing, cement		
	SWL: 225 on January 30, 1965		
	Yields 1,000 gpm with 25" dd after 20 hours		
	February 1, 1965		
	15 minute recovery		
	Meter 63494		

S. F. No. 7449—OS—6-61—2M.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

28139

WATER WELL REPORT

STATE OF WASHINGTON

Start[illegible]d No. W004661
UNIQ[illegible]WELL I.D. #
Water Right Permit No.

(1) OWNER: Name City of Othello Address 512 E Main St. Othello WA 99344

(2) LOCATION OF WELL: County Adams - NE 1/4 SE 1/4 Sec 3 T. 15 N., R 29 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Well # 4

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) 4
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☒ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ______ inches.
Drilled --- feet. Depth of completed well 976 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: ______" Diam. from ______ ft. to ______ ft.
Welded ☐ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations ______ in. by ______ in.
48 perforations from 428 ft. to 436 ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name
Type ______ Model No.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☐ No ☐ To what depth? ______ ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name ---
Type: ______ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 396 ft. below top of well Date 1/24/94
Artesian pressure ______ lbs. per square inch Date
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Existing well drilled 1965; to 905'		
Deepened in 1992 to 1450'		
Irrigators Inc. was retained by City of Othello to eliminate upflow & downflow of water in well		
1) Existing 12" casing perforated	428	436
Set bridge	-	440
Cemented Perforated casing	416.5	440
Drilled out cement plug - down flow from behind bottom of casing eliminated		
2) Backfilled with chlorinated pea- gravel	994	1450
Backfilled with bentonite chips	979	994
Pressure grouted with neat cement	976	979
Upflow from Grande Rhonde Aquifer eliminated		
Well was video logged to verify sealing of Aquifers		---

Work Started 12/1/93, 19. Completed 1/13, 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME IRRIGATORS, INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P O BOX 449 Moses Lk WA 98837
(Signed) Delos Boyce (WELL DRILLER) License No. 1064
Contractor's Registration No. IRRIGI*1160J Date 1/11/~~96~~, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W004661
UNIQUE WELL I.D. # #4
Water Right Permit No. #5338 - A

(1) OWNER: Name City of Othello Address 735 E Main Othello WA 99357

(2) LOCATION OF WELL: County Adams NW 1/4 SE 1/4 Sec 3 T. 15N N., R. 29E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) 4
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned XX Method: Dug ☐ Cable XX Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ______ inches.
Drilled ______ feet. Depth of completed well ______ ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: ______" Diam. from ______ ft. to ______ ft.
Welded ☐ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______" Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes XX No ☐
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from 428 ft. to 436 ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☐ No ☐ To what depth? ______ ft.
Material used in seal ______
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level ______ ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Gravel Filled and Bentonite Seal		
Lower 480' of Well		
Concrete Seal Bottom of		
Existing 12" Casing		
Final Well Depth		976'

RECEIVED DEC 20 1995 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED NOV DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 12-1-93, 19. Completed 1-13, 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Irrigators, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address PO Box 449
(Signed) Tom Pryor (WELL DRILLER) License No. 2112
Contractor's Registration No. IRRIGI*1160J Date Oct. 31, 1995

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy
124458

WATER WELL REPORT
STATE OF WASHINGTON

Notice of Intent W07498
UNIQUE WELL I.D. # AAS228
Water Right Permit No. Declaration of GW Claim #150

(1) OWNER: Name City of Othello Address 500 East Main, Othello, WA 99344

(2) LOCATION OF WELL: County Adams SW 1/4 SW 1/4 Sec 26 T 16 N.R. 29E WM
(2a) STREET ADDRESS OF WELL: (or nearest address) None Assigned ENE of intersection of Lee w/ Reynolds
TAX PARCEL NO.:

(3) PROPOSED USE: ☐ Domestic ☐ Industrial ☒ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one) 8
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☐ Jetted

(5) DIMENSIONS: Diameter of well 24x20 inches
Drilled 951 feet. Depth of completed well 853 ft.

(6) CONSTRUCTION DETAILS
Casing Installed:
☒ Welded 20" Diam. from +3 ft. to 398 ft.
☐ Liner installed 24" Diam. from 2 ft. to 203.5 ft.
☐ Threaded " Diam. from ft. to ft.

Perforations: ☐ Yes ☒ No
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location
Manufacturer's Name
Type Model No.
Diam. Slot Size from ft. to ft.
Diam. Slot Size from ft. to ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand
Material placed from ft. to ft.

Surface seal: ☒ Yes ☐ No To what depth? 398 ft.
Material used in seal cement grout
Did any strata contain unusable water? ☒ Yes ☐ No
Type of water? high flouride & odor Depth of strata 913-932±
Method of sealing strata off cement grout (see item #10)

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ~ 1120 ft.
Static level 380.5 ft. below top of well Date 11/18/02
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? SEI
Yield: See ~~XXXXXX~~ attached graph ft. drawdown after hrs.
Yield: gal./min. with ft. drawdown after hrs.
Yield: gal./min. with ft. drawdown after hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time | Water Level | Time | Water Level | Time | Water Level
See attached graph

Date of test 11/18-20/02
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 75° F Was a chemical analysis made? ☒ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered.

MATERIAL	FROM	TO
see attached log		
Steel plate welded between		
casings at top of 24" casing.		
Lower hole abandonment as		
approved by DOE variance:		
slough & large gravel	853	870
cement grout	870	890
pea gravel w/ sand	890	933
cement grout	933	951

RECEIVED DEC 06 2002 DEPT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 7/17/02. Completed 11/26/02.

WELL CONSTRUCTION CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name Steve Schneider License No. 0643
(Licensed Driller/Engineer) et al
Trainee Name License No.
Drilling Company Schneider Equipment, Inc.
(Signed) Stephen Schneider License No. 643
(Licensed Driller/Engineer)
Address 21881 River Rd NE, St. Paul, OR 97137
Contractor's Registration No. SCHNEI*226LG Date 12/6/02

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (360) 407-6600. The TDD number is (360) 407-6006.

ECY 050-1-20 (11/98)

124458

City of Othello Well No 8

by Schneider Drilling Co

Start Card #W07498 Label #AAS228

FM	TO	DESCRIPTION
0	4	Sandy loam
4	7	Sandy loam & gravel w/ cobbles
7	12	Cobbles, gravel, & claystone, pink (caliche)
12	28	Claystone, pink, soft & gravel, brown w/ cobbles
28	68	Claystone, pink & gravel, cobbles & occasional boulder
68	108	Claystone, grey & pink, soft
108	120	Clay, tan - brown, sticky, medium
120	140	Sandstone, brown, medium, weathered & clay, tan
140	160	Sandstone, brown, medium, weathered
160	165	Sandstone, brown & clay, grey, sticky
165	200	Clay, grey, soft-medium
200	213	Clay, tan - grey, stcky, medium
213	216	Basalt, black, medium, fractured
216	243	Basalt, grey, hard, fractured
243	244	Basalt, brown, medium, fractured
244	248	Basalt, brown, medium, broken
248	252	Basalt, brown, soft, vesicular, broken w/ claystone, yellow
252	258	Basalt, brown & grey, medium, well fractured
258	281	Basalt, brown, soft, vesicular, broken w/ claystone, yellow
281	437	Basalt, grey, hard, some fractures
437	444	Basalt, black, hard, fractured, w/ trace of clay, green
444	517	Basalt, black turning to grey w/ depth, very hard, fractured
517	528	Basalt, black, hard, fractured
528	529	Clay & sandstone, brown & tan & basalt, black, medium-soft
529	569	Basalt, black, soft, broken, vesicular (blue-green in vesicles)
569	592	Basalt, black, hard, some fractures
592	593	Basalt, black, soft, fractured
593	602	Basalt, black, soft, broken, fractured, vesicular
602	612	Basalt, dark grey, medium, fractured

612	619	Basalt, black, medium-soft, fractured, vesicular w/ some claystone, green
619	640	Basalt, grey, medium-hard, fractured
640	670	Basalt, black, medium-soft, broken w/ some claystone, green
670	674	Basalt, dark grey, hard fractured
674	683	Basalt, black w/some brown, medium, fractured, vesicular w/some claystone, green
683	687	Basalt, dark grey w/pink & green tints, soft, cindery, vesicular
687	695	Basalt, dark grey, medium, some fractures
695	697	Basalt, dark grey, medium, fractured
697	700	Basalt, dark grey, medium, fractured, w/ claystone, green
700	708	Basalt, dark grey, medium, fractured, w/ claystone, blue-green
708	723	Basalt, dark grey, medium-hard, fractured
723	739	Basalt, dark grey, medium, fractured w/vesicles
739	743	Basalt, dark grey, hard-medium, fractured
743	761	Basalt, dark grey, medium, fractured, w/ vesicles
761	763	Basalt, dark grey, medium-hard, fractured
763	780	Basalt, dark grey, hard, some fractures
780	798	Basalt, black, medium, fractured, vesicular
798	833	Basalt, dark grey, hard, some fractures
833	838	Basalt, dark grey, medium, some fractures w/occasional vesicles
838	839	Basalt, dark grey, hard, fractured w/occasional vesicles
839	840	Basalt, dark grey, medium, some fractures w/occasional vesicles & claystone, green
840	844	Basalt, dark grey, medium, some fractures w/occasional vesicles
844	858	Basalt, dark grey, medium, some fractures
858	905	Basalt, dark grey, hard, very few fractures
905	910	Basalt, black, medium, fractured
910	914	Basalt, black, soft, fractured, vesicular w/claystone, green & grey
914	915	Clay, green w/some basalt, dark grey
915	932	Basalt, dark grey, soft, fractured w/claystone, green
932	937	Basalt, grey, medium, fractured w/claystone, green
937	948	Basalt, dark grey, medium, fractured w/claystone, green
948	951	Basalt, grey, hard, some fractures

434387

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

CURRENT
Notice of Intent No. W 253012

Unique Ecology Well ID Tag No. N/A

Water Right Permit No. G3-25032 P

Property Owner Name City of Othello

Well Street Address

City ______ County Adams

Location NE 1/4-1/4 NE 1/4 Sec 4 Twn 15 R 29 (EWM) or WWM circle one

Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No.

Construction/Decommission (*"x" in circle*)
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

PROPOSED USE: ☐ Domestic ☐ Industrial ☒ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) Well #6
☐ New well ☒ Reconditioned ☐ Deepened
Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well — inches, drilled — ft.
Depth of completed well 1002' ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded ____" Diam. from ____ ft. to ____ ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded 20"" Diam. from +1 ft. to 212' ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 52' ft.
Material used in seal cement by others
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 536' ft. below top of well Date 2/22/2011
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Layne
Yield: 2000 gal./min. with 60' ft. drawdown after 12 hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

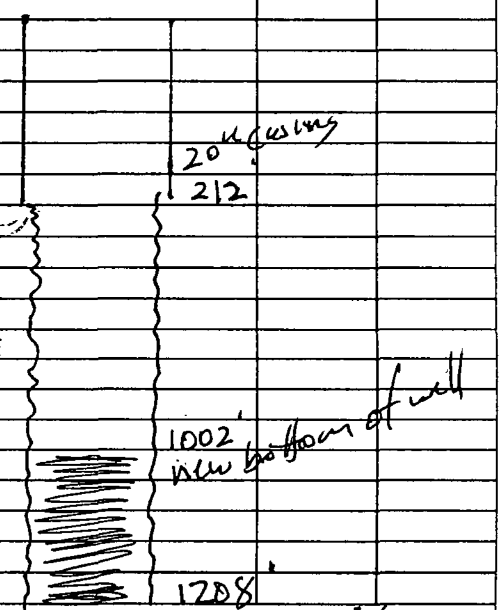
Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ______
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Well #6 was drilled in 1977 Well screen assembly was pulled out and the bottom of the borehole is now 1002' The bottom section where the screen was is filled with cement grout installed by tremie		



RECEIVED
JUL 25 2011
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 12/2010 Completed Date 6/2011

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Randy Holt
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 1099

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company Holt Services Inc
Address 13000 Lakeholme Rd SW
City, State, Zip Lakewood Wa 98498
Contractor's Registration No HOLTSSI930KP Date ______

Ecology is an Equal Opportunity Employer

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☐ Construction
☒ Decommission *ORIGINAL INSTALLATION*
Notice of Intent Number none

CURRENT

Notice of Intent No. AE27371
Unique Ecology Well ID Tag No. AAR990
Water Right Permit No.
Property Owner Name City of Othello
Well Street Address 136 South Broadway
City Othello County Adams
Location NE1/4-1/4 NE1/4 Sec 4 Twn 15N R 29 EWM ☒ Or WWM ☐
(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. (Required) 1529030502511

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) 1
☐ New well ☐ Reconditioned *Method :* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 10 inches, drilled ? ft.
Depth of completed well ? ft. unknown original

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded 10" Diam. from +0.5 ft. to ? ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☐ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☐ No ☐ K-Pac Location ____
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☐ No Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☐ Yes ☐ No To what depth? ____ ft.
Material used in seal ____
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 270 ft. below top of well Date 8/13/14
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

Note: Not WL of completed well.

Decommissioning

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Well was reportedly driled		
circa 1909.		
Placed unhydrated chip		
bentonite in uncased hole		
from bottom of well (545')		
to bottom of casing (211').		
Perforated casing (4 around		
every foot) from its		
bottom up to ground		
surface.		
Pumped cement grout under		
pressure from bottom of		
casing to surface.		
Well had 10" Ø casing. Was 545' deep.		
270' SWL prior to decommissioning		

RECEIVED SEP 10 2014 Department of Ecology Eastern Regional Office

RECEIVED MAR 10 2015 Department of Ecology Eastern Washington Office

Start Date 8/13/14 Completed Date 8/19/14

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Steve Schneider	Drilling Company Schneider Water Services
Driller/Engineer/Trainee Signature [signature]	Address 21881 River Road NE
Driller or trainee License No. 0643	City, State, Zip St. Paul, OR, 97137
IF TRAINEE: Driller's License No:	Contractor's
Driller's Signature:	Registration No. SCHNEEI940R8 Date 9/3/14

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Decla. #150
Cert. #182-D

Date June 1, 1909

Record by J. H. Barrett

Source G. W. Decla. Claim

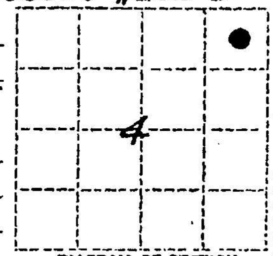


DIAGRAM OF SECTION

Location: State of WASHINGTON

County Adams

Area

Map

NE ¼ NE ¼ sec. 4 T. 15 N., R. 29 E.

Drilling Co.

Address

Method of Drilling Drilled Date June 1 1909

Owner Town of Othello

Address Othello, Wash.

Land surface, datum 1050 ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)			
	Well log:		
	Glacial deposits	140	140
	Basaltic formation	421	561
	Pump Test:		
	Dim.: 561' deep; 8" diam.		
	SWL: No data		
	DD: No data		
	Yield: No data (200 g.p.m. in Cert.		
	Casing: 8" diam. steel casing from		
	surface to 120'		
	Perfs.: No data		
	Type & Size of Pump: Deep well turb:		
	pump		
	" " " " Motor: Electric motor		

Turn up

Sheet ____ of ____ sheets

MEMORANDUM

Project No.: 150143

June 21, 2016

To: Jesse Cowger, PE, Varela Associates

cc: Wade Farris, City Administrator
City of Othello

Hydrogeologist
795
State of Washington Licensed Geologist
Joseph N. Morrice

From: Joe Morrice, LHG
Associate Hydrogeologist
jmorrice@aspectconsulting.com

Tim Flynn, LHG, CGWP
Principal Hydrogeologist
tflynn@aspectconsulting.com

Re: **Evaluation and Recommendations for Groundwater Supply Improvements**

Aspect Consulting, LLC (Aspect) was retained by the City of Othello (City), under subcontract to Varela & Associates, Inc. (Varela), to provide water supply planning and hydrogeologic support services, including:

- Identifying and assessing likely causes of well yield performance issues; and
- Assessing groundwater supply options to sustain existing wellfield capacity and offset anticipated future declines in yields from the City's groundwater supply wells, while the City evaluates long-term water supply options to increase capacity, including water reuse or a potential surface water source.

The evaluation of well performance issues was provided in the draft *City of Othello Water Supply Well Assessment* (Aspect, 2016)[1], which determined:

- Historical and ongoing area-wide declines in water levels are leading to higher pumping lifts and associated loss in well yields;

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[1] Aspect Consulting, 2016. City of Othello Water Supply Well Assessment, DRAFT Memorandum to Varela & Associates. February 12, 2016.

- Local drawdown interference between City and other private wells also contributes to lost yield, but is a minor effect relative to area-wide declines in water levels;
- Operationally, the City manages pumping of the well field effectively to maximize yields and minimize drawdown interference;
- Well efficiencies do not appear to have decreased over time, except at Well 7, which was completed with a well screen and liner and may benefit from rehabilitation.

This memorandum builds on results of the previous work to provide recommended water supply improvements and actions to maintain and enhance the capacity and reliability of the available groundwater supply. The following sections provide a summary of findings and recommended water supply improvements; evaluation of current and projected future groundwater source capacity; and a description and evaluation of potential benefits, costs, and risks of selected water supply improvement options.

Summary of Findings and Recommendations

The current maximum instantaneous capacity of the City's source wells, including recently installed Well 9, is about 7,500 gallons per minute (gpm). Current source capacity exceeds Washington Department of Health (DOH) water system design guidance recommendations for system reliability based on meeting average day demand (ADD), maximum day demand (MDD), and fire flow requirements. The calculated instantaneous capacity of the wells needed to meet reliability recommendations ranges from 2,820 gpm to meet ADD with the largest well source offline[2] to 6,010 gpm to meet MDD within 18 hours of pumping. Based on comparison of these recommended values to well capacities, the ability to meet MDD within 18 hours of pumping is the primary challenge for sustaining current service reliability and accommodating future growth in water demands.

Historical and ongoing water level declines in the City's production wells have resulted in reduced well yields over time. Recent initiatives by the State of Washington to reduce the reliance of irrigated agriculture on groundwater (through source exchange with surface water) may moderate the rate of aquifer depletion over the long-term; however, water levels and correspondingly yields of wells completed in the Wanapum Basalt Aquifer are expected to continue to decline for several years before these effects are realized.

Currently, all of the City's wells are completed in the Wanapum Basalt Aquifer, which is the primary aquifer zone supporting groundwater supplies in the Columbia Basin project. Based on a review of water level trends and yield data described below, the City may have been losing up to 200 gpm of wellfield production capacity per year. At this rate of decline, and assuming no growth in demands or new source capacity, the water system would be unable to meet MDD within 18 hours of pumping in approximately seven to eight years.

Efforts by the City and McCain Foods, Inc. to develop additional water supply capacity by installing new wells and spreading pumping from the Wanapum Basalt over a greater area is expected to help moderate declines in water levels and well yields, especially peak seasonal pumping capacity, by reducing drawdown interference between wells. These wells were only

[2] With the largest source off-line (Well 6), source well capacity would be about 5,100 gpm, rather than 7,500 gpm.

recently put into operation, and several years of yield and water level data would be required to develop a new projection of well yield changes over time; however, even a modest improvement in the loss of well yields would extend the timeline for when the system would not meet the MDD within 18 hours of pumping reliability criterion to 10 to 15 years. Conversely, accommodating growth in non-industrial water uses would increase peak demands and reduce this timeline, depending on the rate of growth.

It is important to note that these timelines are based on meeting DOH recommendations for system reliability and do not necessarily indicate the City will be unable to meet customer demands in the near future. However, the system demands and source capacities do indicate that the water system may face reliability concerns, especially if a well source were lost during periods of peak demand.

This timeline could be extended by adding groundwater supply capacity to offset reductions in yields from existing wells. However, groundwater supply improvements alone (in the Wanapum Basalt Aquifer) would likely not be sufficient to support additional industrial or commercial uses. Water supply for these uses will likely require an alternate source of water, such as treated surface water and/or reuse of industrial wastewater, to ensure long-term sustainability. These potential water sources could be used to augment existing groundwater supply to meet future water supply needs as well as provide an opportunity to sustain the City's existing wellfield infrastructure through aquifer storage and recovery (ASR). The ASR option will be evaluated as part of the pending Washington State Department of Ecology (Ecology) Office of Columbia River (OCR) grant-funded ASR Feasibility Study (FS) and is not considered further in this memorandum.

Based on the observed historical declines in water levels and well yields and anticipated moderation of these declines in the future by spreading pumping over a greater area, we recommend a planning horizon of five years to bring new groundwater source capacity online. This would allow the City to maintain a high level of system reliability as other alternate sources (surface water or industrial reuse) are evaluated and developed, while also accommodating modest growth in non-industrial water demands. Based on our prior assessment of likely causes of lost well yield and the evaluation of selected water supply improvement options described in this memorandum, we recommend the following actions to maintain and improve groundwater supply capacity and reliability:

1. **Rehabilitate Well 7.** This well was constructed in 1998 on the southwest side of the City (Figure 1) and completed with a liner and well screen assembly. Initial yields from this well were about 1,200 gpm, but have declined to less than 1,000 gpm in 2008 and about 600 to 650 gpm in 2015. Regaining even half the lost well capacity would provide an additional 300 gpm. We recommend completing mechanical rehabilitation of this well and well screen to improve yields. This would include:

   - Completing a step-rate pumping test to document current performance;
   - Removing or demolishing the existing well house building;
   - Removing the pump and pump column, inspecting the pump assembly, and completing a video survey to document existing well screen conditions;
   - Mechanically rehabilitating the well (swabbing, surging, jetting) by a licensed well contractor;

- Resetting the pump and column and completing a step-rate pumping test to assess the efficacy of well rehabilitation; and
- Replacing the well house building.

Although the potential increase in yields is modest, the costs are relatively low and this could be implemented over the near-term without additional Ecology permitting or approval. We estimate rehabilitation of Well 7 would cost about $50,000, not including pump repairs or removal of the well house to access the well, if needed. If funding is available, we recommend implementing this work in winter 2016/2017, during low water system demands, when Well 7 could be taken offline without affecting the City's ability to meet water system demands.

2. **Install New Wanapum Well.** Two options for a new well completed in the Wanapum Basalt Aquifer were evaluated, including locations east of the City at or near the Well 9 site and west of the City at Taggares County Park, near the Adams County Water District No. 1 (Water District No. 1) service area.

   - Well 9 site. Estimates of drawdown interference at the Well 9 site indicate a new well could be operated only at limited capacity (e.g., about 500 to 650 gpm) before impacting yields at Well 9. Higher yields could be achievable by locating a well further south of the Well 9 site, but would require property acquisition and construction of additional conveyance infrastructure.
   - Taggares County Park site. The well site in Taggares County Park is about 1 mile west of the City. Water District No. 1 is served by the City through an intertie and has no existing sources or water rights of its own. A new well at this location could likely take partial advantage of existing infrastructure, but would require construction of conveyance to bypass a pressure reducing valve at the intertie and a well pump station for distribution to the Water District and City. We understand that Washington State Department of Health funding may be available to assist in developing capacity and resiliency of the Water District No. 1 system, although the level of funding and specific activities that could be funded have not been determined.

     For this option, we have assumed a new well, owned by the City, would be drilled in Taggares County Park with a target yield of about 1,500 gpm. A well in this location would be more than one mile west of the nearest City well (Well 6), reducing the effects of interference drawdown between wells. Currently, none of the City's water rights includes this location as an authorized point of withdrawal for a well. Water right permitting would need to be completed through either Ecology or the Adams County Water Conservancy Board to add the new well location as a point of withdrawal to one or more of the City's water rights before putting water to use.

     A new well tapping the Wanapum Basalt Aquifer at this location would likely extend to a total depth of about 1,000 feet. Assuming a final, 16-inch-diameter completed well, cost for well construction, testing, and construction oversight would be about $700,000 to $800,000, not including costs for permitting, purchase and installation of the well pump station.

3. **Explore Grande Ronde Basalt Aquifer.** The two primary water supply aquifers present in the Othello Area are the Wanapum Basalt Aquifer and the underlying Grande Ronde Basalt Aquifer; all the City's wells currently tap the Wanapum Basalt Aquifer. The wells closest to the

City tapping the Grand Ronde are located about ten miles to the east and 12 miles to the northwest, making the Grand Ronde a potentially attractive target for a new well. In addition, a new water supply well in the Grande Ronde Basalt Aquifer could be completed in close proximity to one of the City's existing wells without incurring the interference drawdown associated with completing a new well in the Wanapum Basalt Aquifer. However, because of the lack of other existing wells near the City, the potential yields, required drilling depths to tap water bearing zones, and water quality of the Grande Ronde Basalt Aquifer are uncertain. The limited available data suggest the upper 1,000 feet of the Grande Ronde Basalt has the potential for producing high yields, and a production well completed in this aquifer would likely need to extend more than 2,000 feet below grade to tap sufficient water bearing zones to be a viable source. Further, the available water quality data indicates the potential for elevated fluoride concentrations, which may require treatment or blending prior to distribution.

Given these concerns and the limited data available, we recommend first contacting owners of the deep wells east and northwest of the City to inquire about well yields, water level trends, and access to collect water quality data. This information would provide the City with a better understanding of whether a new well tapping the Grande Ronde Basalt Aquifer would be cost effective and a more viable source of supply than the Wanapum Basalt Aquifer. If additional information on well yields and water quality indicate the Grande Ronde may be a viable source of supply, we would then recommend drilling of a test well into the Grande Ronde.

The most cost-effective approach for exploration drilling of the Grande Ronde would be to combine the effort with drilling a new well completed in the Wanapum (e.g., at Water District No. 1) or potentially utilizing an existing City well. This would involve extending the borehole past the bottom of the Wanapum Basalt into the Grande Ronde to allow for hydraulic and water quality testing. Following testing of the Grande Ronde, the lower portion of the borehole would be abandoned and the well completed in the Wanapum Basalt Aquifer. Alternately, a stand-alone test well could be drilled into the Grand Ronde Basalt, but at higher cost. Results of the exploration drilling would be used to assess the viability of the Grande Ronde Basalt Aquifer as a source of supply.

We've assumed that exploration into the Grande Ronde would consist of drilling an uncased, 8-inch-diameter boring past the bottom of the Wanapum Basalt and about 1,000 feet into the Grande Ronde Basalt to test for yield and water quality. Estimated costs would be on the order of $250,000 to $350,000, in addition to costs for construction of a Wanapum well if an existing City well is not used. Drilling and testing of a 2,000-foot-deep, stand-alone test well would be on the order of $500,000 to $700,000.

If the test boring indicates the Grande Ronde Basalt is a viable source of supply, the boring could be reamed to a larger diameter and completed as a Grande Ronde production well. Collocating this with an existing City well (e.g., the Well 9 site) would also allow blending with a Wanapum Basalt source, if needed to address fluoride or other water quality concerns.

Current and Projected Source Capacity and Reliability Criteria

This section provides a summary of current water system capacity, estimated future decreases in capacity assuming water levels in the Wanapum Basalt Aquifer continue to decline at historical rates, and implications for meeting current and limited future growth in water system demands.

Based on review of City well production and water level data, and accounting for new production capacity from Well 9, current water system capacity to meet peak demands is estimated at approximately 7,500 gpm, sufficient to meet current peak demands. Assuming decreases in water levels in the Wanapum Basalt Aquifer continue at this rate, water system capacity may decrease in the future by as much as 200 gpm per year. At this rate of decrease, the water system would be unable to meet DOH design recommendations for instantaneous well capacity to provide the MDD in 18 hours of pumping (about 6,000 gpm) in approximately seven to eight years. This does not account for recent efforts by the City and McCain Foods, which operates its own water supply wells, to develop new well sources west and east of the City. These new sources will spread pumping from the Wanapum basalt over a larger area, reducing drawdown interference between wells, especially during peak demands. A modest, 25 percent improvement in future loss of well yields (e.g., from 200 to 150 gpm per year) would extend this timeline to about ten years, and a 50 percent improvement in future loss of well yields would extend this timeline to about 15 years.

The following sections provide a summary of the data and analyses on which the above information is based.

Estimated System Capacity

System capacity was based on review of City well production and water level data available for the periods of September 24, 2007 through May 19, 2009 (referred to in this report as the 2008 data) and November 4, 2014 through November 8, 2015 (referred to in this report as the 2015 data). These data do not include production capacity from the recently completed Well 9, which is equipped with a pump sized to deliver 1,500 gpm. The 2008 data showed peak water system production in June 2008 on the order of 5,200 gpm, with average production over the peak month of water use of about 4,000 gpm. The 2015 data showed peak system production in July 2015 on the order of 6,000 gpm, with average production over the peak month of water use of about 4,600 gpm. Maximum yields by well are summarized in Table 1. Based on the maximum 2015 yields of about 6,000 gpm and accounting for the additional 1,500 gpm expected from Well 9, total system instantaneous pumping capacity is about 7,500 gpm.

Table 1 – Maximum Well Yields

Well Number	2008 Maximum Yield (gpm)	2015 Maximum Yield (gpm)
2	300	0
3	1,200	900
4	500	420
5	1,400	1,200
6	0	2,400
7	1,000	650
8	800	400
9	NA	NA
Total	5,200	5,970

NA - Not Applicable. Well 9 was not on-line, but is designed to produce 1,500 gpm.

Estimated Future Decreases in System Capacity

As water levels in the Wanapum Basalt Aquifer continue to decline regionally, system capacity will also decline. Historically, the average water level decline has been about 2 feet per year, although this rate is uncertain and based on limited data. The expected decrease in yield per year can be estimated by multiplying the specific capacity of each well by the estimated rate of water level decline. Results are provided in Table 2. Assuming continued water level declines of 2 feet per year results in an estimated loss in system capacity of about 200 gpm per year.

Table 2 – Estimated Annual Loss in Yield from Area-Wide Water Level Declines

Well Number	Source of Specific Capacity Estimate	Specific Capacity (gpm/ft)	Estimated Annual Loss in Yield (gpm) [1]
2	Driller's Log	Data not available	Data not available
3	City telemetry	18	36
4	City telemetry	13	26
5	City telemetry	12	23
6	City telemetry	36	71
7	City telemetry	1.9	4
8	City telemetry	3.1	6
9	Well Test	9.3	19
		Total	185

[1] Assuming an annual decline in water levels of 2 feet.

These estimates do not account for recent efforts by McCain Foods and the City to install new wells to the east (City Well 9) and west (McCain Foods Well 4) of the City. These wells will spread local pumping from the Wanapum Basalt over a larger area, decreasing drawdown interference between wells, especially during the peak pumping season. Spreading pumping is expected to reduce the rate of well yield loss, although additional water level and well yield data since the new wells were brought online would be required to develop a reliable projection for future losses. To account for this effect on projected water system capacity, the annual rate of lost peak season well yield was assumed to improve by between 25 and 50 percent in response to spreading of pumping.

Water System Reliability Criteria

The DOH Water System Design Manual (DOH, 2009) includes several criteria for assessing water system source capacity to ensure a high level of water system reliability, including:

- With the largest source out of service, remaining sources can provide ADD for the water system;
- Combined source capacity can provide the MDD in a period of 18 hours of pumping or less; and
- Source capacity can supply MDD and replenish fire flow storage within 72 hours.

The 2010 draft Water System Plan (Gray and Osborne, 2010) provided estimated MDD and ADD values of about 2,820 and 4,510 gpm, respectively. The draft Water System Plan also provided recommended total source capacities to meet each of the DOH reliability criteria, as summarized in

Table 3. From this, the most restrictive recommendation is to meet MDD within 18 hours of pumping, with a recommended source capacity of about 6,000 gpm.

Table 3 – DOH Source Capacity Recommendations

DOH Design Requirement	Recommended Qi (gpm)	Available Qi (gpm)	Surplus Qi (gpm)
Meet ADD without largest source	2,820	5,100	3,280
Meet MDD within 18 hours of pumping	6,010	7,500	1,490
Meet MDD and replenish fire flow within 72 hours	4,860	7,500	2,640

Notes:
DOH - Department of Health
ADD - Average Day Demand
MDD - Maximum Day Demand
Qi - Instantaneous flow rate
gpm - gallons per minute
The Qi available is 7,500 gpm with all sources operating, and 5,100 with the largest source (Well 6) off-line.

Water Supply Improvement Options

This section provides evaluation of selected water supply improvement options to maintain and increase the City's groundwater source capacity. The selected options are focused on maintaining current groundwater supply capacity to meet current uses, and provide for limited additional growth in demands. Given the high demands that industrial users (e.g., food processors) typically require, it is expected that significant future commercial or industrial growth will require alternate sources of supply, such as treated surface water and/or reuse of industrial wastewater.

Rehabilitation of Well 7 to Restore Lost Capacity

Aspect reviewed well production and water level data, well construction logs, and hydrogeologic information to assess performance issues with the City's wells (Aspect, 2016). The assessment distinguished between loss of production due to decreasing aquifer water levels versus loss of production due to decreased well efficiency (e.g., fouling or plugging of the well screen or aquifer formation). This work concluded that the City's wells do not show an observable decrease in well efficiency over time, except for Well 7. This well was constructed with a stainless steel screen (all other wells except Well 6 are completed primarily with open borehole in the water bearing zones, with limited perforated casing sections) and has shown about a 50 percent loss in specific capacity since it was constructed in 1998. Yields have also declined, from about 1,200 gallons per minute gpm when constructed to less than 1,000 gpm in 2008 and about 600 to 650 gpm in 2015. If about half the lost specific capacity can be recovered this well may sustain on the order of an additional 300 gpm.

We recommend mechanical rehabilitation (e.g., surging, swabbing, brushing, jetting) of the well screen in well 7 to improve yield. This would include:

- Completing a short-term, step-rate pumping test to document current well efficiency and specific capacity.

- Removing or demolishing the well house building and removing the pump and pump column. We also recommend including an inspection of the pump and assembly once removed to assess for wear or damage.
- Completing a video survey to document existing conditions and identify casing obstructions or damage to the well screen that would limit rehabilitation efforts.
- Mechanical rehabilitation by a licensed well contractor.
- Resetting the pump and column and completing a step-rate pumping test to assess the efficacy of well rehabilitation.
- Replacing or reconstructing the well house building.

Based on recent driller's quotes for similar work we estimate rehabilitation of Well 7 outlined above would cost about $50,000, not including pump repairs or removal and replacement of the well house, if needed. If funding is available, recommend implementing this work in winter 2016/2017 during low water system demands.

New Water Supply Well

A new water supply well or wells could be constructed to increase water system capacity. The potential costs, benefits, and risks of a new well will depend on well location and aquifer targeted as the source of supply.

Two potential well locations are evaluated and discussed below, including:

- At or near the Well 9 site east of the City; and
- West of the City, near the Water District No. 1 service area.

Currently the City's wells all tap the Wanapum Basalt Aquifer, which is also the primary source of groundwater supply for other agricultural and industrial water users in the area. Alternately, a well could be completed in the Grande Ronde Basalt Aquifer, which underlies the Wanapum Basalt Aquifer. Considerations for target aquifer for well completion (Grande Ronde versus Wanapum Basalt) and for well siting at the identified locations are discussed in the following sections.

Wanapum Basalt versus Grande Ronde Basalt Well Completion

The two primary water supply aquifers present in the Othello Area are the Wanapum Basalt Aquifer and the underlying Grande Ronde Basalt Aquifer. All the City's wells tap the Wanapum Basalt Aquifer, which has experienced declines in water levels, reducing well yields over time, and is expected to continue declining into the future. To maximize production, a new well completed in the Wanapum Basalt Aquifer should be located so as to minimize drawdown interference with other existing City or private wells.

Based on our review of water rights and well logs, the nearest wells to the City tapping the Grande Ronde Basalt Aquifer is a set of wells located about nine to ten miles east of the City, and another set of wells located about 12 miles northwest of the City near Potholes Reservoir. The lack of other water wells closer to the City makes the Grande Ronde Basalt Aquifer a potentially attractive target for a new well, as drawdown interference from other wells would be significantly reduced or eliminated. This would allow construction of a Grande Ronde well on City property, either at the Well 9 site or other City properties containing wells. However, the potential yields, required drilling depths to tap water bearing zones, and water quality of the Grande Ronde Basalt Aquifer in the area are uncertain, making it a riskier target for the City to develop than the better characterized Wanapum Basalt Aquifer.

Limited information on water quality and potential water bearing zones in the Grande Ronde Basalt Aquifer are available from the drilling of the City's Well 9 and a private water supply well recently constructed west of the City. Additional information on depth to and yield from the Grande Ronde is available from driller's logs for two sets of irrigation wells located about 12 miles northeast and about ten miles east of the City, respectively.

The boring for City Well 9 extended about 200 feet below the bottom of the Wanapum Basalt into the Grande Ronde Basalt, and identified a likely water bearing zone in a brecciated basalt flow top at a depth of about 1,115 feet. When this zone was encountered, water levels in the well decreased and a subsequent video survey showed water flowing out of the boring at this depth; potential water yield from this zone or the presence of additional water bearing zones at below this depth is unknown. Water quality samples were collected during drilling with the borehole open to both the Wanapum and Grande Ronde Basalts and analyzed for fluoride. Reported fluoride concentrations were less than 1 milligram per liter (mg/L), which is less than both the federal drinking water primary Maximum Contaminant Level (MCL) and secondary MCL of 4 and 2 mg/L, respectively. Because the borehole was open to both the Grande Ronde and Wanapum Basalts, reported fluoride concentrations may not be representative of water quality conditions in the Grande Ronde Basalt Aquifer.

The private well west of the City drilled through the Wanapum Basalt and extended about 300 feet into the top of the Grande Ronde Basalt. Potential water bearing zones, based on observation of drill cuttings, were identified at depths of about 1,100 and 1,150 feet. An aquifer test was attempted with the Grande Ronde Basalt isolated from the overlying Wanapum Basalt with a packer assembly. The aquifer test was terminated within an hour after the start of pumping because the very low yield and associated drawdown of water in the Grande Ronde Basalt resulted in failure of the inflatable packer. Water quality samples were collected during drilling in the Grande Ronde Basalt. Reported fluoride concentrations ranged from about 2.5 to 5.5 mg/L, which exceeds the federal secondary MCL, and in one sample the primary MCL.

Two sets of deep irrigation wells area located about 10 to 12 miles northwest and east of the City. Based on review of well logs, these wells tap the Grande Ronde Basalt starting at depths of about 800 to 1,000 feet and extending to depths as great as about 2,500 feet. Short-term, estimated well yields based on air lift tests reported on the well logs range from about 1,000 to more than 2,000 gpm. Although air lift tests are only a rough estimate of potential yield, this information indicates that high yields from the Grande Ronde Basalts in the Othello area are achievable. Water quality and water level trends at these wells is currently unknown. We recommend that these well owners be contacted to gather additional information on well performance and to gain access to collect water quality samples. This would allow the City greater confidence in determining whether a new well tapping the Grande Ronde Basalt Aquifer would be cost effective and a more viable source of supply than the Wanapum Basalt Aquifer.

Because of the lack of other wells completed in the Grande Ronde near the City, a new well tapping the Grande Ronde could be located at one of the City's existing well sites within City limits or at the Well 9 site without interference drawdown with the City's Wanapum wells. If additional information on well yields and water quality indicate the Grande Ronde may be a viable source of supply, we would then recommend drilling of a test well into the Grande Ronde, either as a stand-alone effort or as additional exploration during drilling of a Wanapum Basalt Aquifer well (e.g., at Water District No. 1).

A test well tapping the Grande Ronde Basalt Aquifer would likely extend to a total depth of about 2,000 feet. Assuming a final, 10-inch-diameter open-hole well completion in the Grande Ronde, cost for well construction, testing, and construction oversight would be about $500,000 to $700,000. Alternately, if exploration of the Grande Ronde were performed through an existing City well or as part of drilling a new Wanapum Basalt Aquifer well, approximate additional costs to extend the exploration about 1,000 feet into the Grande Ronde Basalt and test for yield and water quality would be on the order of $250,000 to $350,000.

New Well at Well 9 Site

The City owns approximately 13 acres of property at the site of new Well 9 that could be used to install an additional well tapping the Wanapum Basalt Aquifer. Alternately, to reduce the potential for drawdown interference with Well 9, a new well could be installed off-property about ½ to one-mile north or south of Well 9. The Well 9 site is preferred, as a new well could make use of recently completed infrastructure, including conveyance from Well 9 to the city distribution system, availability of power supply, and a chlorination station for water treatment. A well located off-property would require property acquisition or an easement and additional conveyance to tie-in to the existing infrastructure.

Water is currently conveyed from Well 9 about 2,000 feet south to Cunningham Road, then west to the City. If the City could acquire access for a new well south of Well 9, construction of additional conveyance to tie-in to the existing main line could be minimized. For example, a new well location less than 2,000 feet south of Well 9 may only need a few tens of feet of conveyance to tie-in, while a well located 0.5 miles (2,640 feet) south of Well 9 would need at least about 640 feet of new conveyance to tie-in at Cunningham Road.

Currently, only one of the City's water rights (Permit G3-25933P) includes the Well 9 property as an authorized point of withdrawal for a well, while none of the water rights include the nearby off-property locations as points of withdrawal. Permit G3-25933P limits water withdrawals to 2,000 gpm, 3,000 acre-feet per year (afy). Although a new well could likely be constructed on-property without additional permitting through what is termed a showing of compliance, under the water right permit the additional capacity that could be realized from the new well would be limited to 500 gpm, regardless of actual yield. Given this constraint, we expect water right permitting through either Ecology or the Adams County Water Conservancy Board (Conservancy Board) will be necessary to add a new well and increase the maximum combined pumping rate, either on-property or off-property, as a point of withdrawal to other City water rights.

The primary concern with siting a Wanapum Basalt Aquifer well near Well 9 is the potential for drawdown interference between the two wells reducing the yields from both. Seasonal low depth to water in Well 9 is about 75 feet below ground surface (bgs), and the recommended pump inlet setting is 380 feet bgs, giving a water column of about 305 feet above the pump inlet (Aspect, 2016). Assuming a target of maintaining 20 feet of water column over the pump inlet during pumping, the total available drawdown in Well 9 is about 285 feet. Results of the pumping test for Well 9 indicated that after six months of pumping at a rate of 1,500 gpm, about 205 feet of drawdown would be expected, leaving about 80 feet of available drawdown over the pump inlet. In order to maintain the 1,500 gpm capacity of Well 9, any new production well should be located and operated at a pumping rate to minimize drawdown interference and loss of available drawdown.

To assess the effect of well location (on-property versus off-property) on estimated drawdown interference, drawdown for an onsite well and several offsite well locations were estimated using the Cooper and Jacob solution for a confined aquifer, as follows:

$$s = \frac{2.3Q}{4\pi T}\ log\left(\frac{2.25Tt}{r^2S}\right)$$

Where:

s = drawdown from static water level in feet;

Q = pumping rate in cubic feet per day (ft^3/day);

T = Aquifer transmissivity in feet squared per day (ft^2/day);

t = Time since start of pumping in days;

r = Distance from pumping well to point of drawdown estimate in feet; and

S = Aquifer storativity (unitless)

Aquifer transmissivity was estimated as about 2,650 ft^2/day from the Well 9 pumping test. Aquifer storativity is unknown, but assumed to be $5x10^{-5}$ based on values for similar basalt aquifers. Well 9 is located at the northern end of the City-owned property; a new well could be located on south end of this parcel about 800 feet from Well 9, which was selected as the distance between wells for a new, on-property well. The drawdown at Well 9 from a new, off-property well was estimated for distances 0.25, 0.5 and one mile from Well 9. Applying the above equation and parameters, and assuming a pumping rate of 1,500 gpm from the new well over a duration of six months, drawdown interference at Well 9 resulting from an on-property or off-property well were calculated as summarized below in Table 4.

Pumping an on-property well at 1,500 gpm continuously for six months results in an estimated increased drawdown at Well 9 of about 90 feet, exceeding the approximately 80 feet of available drawdown at Well 9 while in operation. Drawdown from a well located one mile from Well 9 would still be 58 feet, consuming most of the available drawdown at Well 9. Drawdown interference of this magnitude would be expected to reduce yields from Well 9 over the short-term as pumping lifts increase, as well as exacerbate the expected effects of ongoing, area-wide water level declines on yields from Well 9.

Of note, there is a diminishing improvement in drawdown interference with greater distances from Well 9, with estimated drawdown interference decreasing by about 12 feet each time the distance between wells doubles (e.g., from 0.5 miles to one mile). For example, if the new well were located

2 miles from Well 9, drawdown inference would only decrease from the 58 feet estimated at one-mile distance to about 46 feet. Based on this, in order to minimize drawdown interference while also minimizing costs to construct conveyance to existing City infrastructure, production from a new well will likely need to be limited to a lower pumping rate than 1,500 gpm.

Table 4 – Estimated Interference Drawdown after Six Months of Pumping

Distance from New Well to Well 9 (Feet)	Pumping Rate at New Well (gpm)	Interference Drawdown at Well 9 (Feet)
800 (on-property)	1,500	90
1,320	1,500	82
2,640	1,500	70
5,280	1,500	58

To assess what pumping rates may be achievable at a new well without excessive drawdown interference at Well 9, a maximum allowable drawdown interference of 30 feet was selected and the maximum pumping rates at different distances between wells producing this drawdown were calculated. Although Well 9 is expected to have about 80 feet of available drawdown above the pump inlet while pumping and could accommodate greater interference drawdown over the short-term, limiting interference drawdown to 30 feet would leave about 50 feet of available drawdown to account for expected ongoing declines in water levels. Results of this evaluation are shown in Table 5.

Table 5 – Estimated Maximum Pumping Limited to 30 Feet of Interference Drawdown

Distance from New Well to Well 9 (Feet)	Pumping Rate at New Well (gpm)	Interference Drawdown at Well 9 (Feet)
800 (on-property)	500	30
1,320	550	30
2,640	650	30
5,280	780	30

The estimated drawdown values indicate that about 500 gpm of additional peak system capacity could be realized by locating a well on-property, with about 550 to 600 gpm of additional peak capacity for a new well located 1,320 (0.25 miles) to 2,000 feet south of Well 9. If property access can be arranged, a new well at these distances could tie-in to the City's mainline with minimal additional construction of conveyance. Higher additional yields could be realized with a new well located farther to the south, but at the cost of constructing additional conveyance to Cunningham Road.

A new well tapping the Wanapum Basalt Aquifer would likely extend to a total depth of about 1,000 feet. Assuming a final, 16-inch-diameter well completion, cost for well construction, testing, and construction oversight would be about $700,000 to $800,000, not including costs for purchase and installation of the well pump. Approximate additional costs to extend the exploration about 1,000 feet into the Grande Ronde Basalt and test for yield and water quality would be on the order of $250,000 to $350,000.

The relatively modest expected yields (500 to 650 gpm) from a new Wanapum Basalt Aquifer well completed either on City property or to the south along Cunningham Road may not justify the cost relative to other groundwater supply options.

New Well in Adams County Water District No. 1 Service Area

An alternate location to site a new production well is in the Water District No.1 Group A Water System service area approximately ½ mile west of the City's Well 6. Water District No. 1 is currently served by City through an intertie and has no existing sources or water rights of its own. City deliveries to Water District No.1 account for about 2 percent of annual well withdrawals. We understand Washington State Department of Health funding may be available to assist in developing capacity and improving reliability of the Water District No. 1 system, although the level of funding and specific activities that could be funded have not been determined.

For this option, we have assumed a new well, owned by the City, would be drilled in Taggares County Park, adjacent to the Water District No. 1 service area to directly supply the Water District and provide additional source capacity to the City. A well in his location would be more than one mile west of the nearest City well (Well 6) and about ½ mile south of a proposed but yet to be built private well, reducing the potential for interference drawdown. This option could likely take partial advantage of the existing intertie to deliver water in excess of Water District No. 1 demands to the City, but would require construction of additional conveyance to bypass a pressure reducing valve on the intertie. Currently, none of the City's water rights includes this location as an authorized point of withdrawal for a well. Water right permitting would need to be completed through either Ecology or the Conservancy Board to add the new well location as a point of withdrawal to one or more of the City's water rights before putting water to use.

The potential for drawdown interference between a new well and City Well 6 was evaluated based on observed drawdown while pumping Well 6 in 2015. Well 6 was not used during the summer of 2015 until July 10, when it was put into operation. Well 6 was then pumped at an average rate of about 1,500 gpm until September 3, when average pumping rates were decreased. Prior to July 10 and extending to September 3 all City wells, except Well 2, were in continuous or near continuous operation; Well 2 remained offline for this period.

Water level data from the City's SCADA system were reviewed to identify the amount of drawdown interference after Well 6 was put back into production in July 2015. Table 6 summarizes observed drawdown and distance from each well to Well 6. A clear drawdown response was not observed at Wells 4, 7, and 8, partially due to more variable pumping rates at these wells. A clear drawdown response was observed at Wells 2, 3, and 5, with drawdown of between about 15 and 28 feet.

Table 6 – Observed Drawdown while Pumping Well 6

Well ID	Observed Drawdown (feet)	Distance from Well 6 (feet)
2	28	1,500
3	25	6,500
4	NA	7,500
5	15	6,800
7	NA	10,000
8	NA	10,000

NA - Not Applicable. No clear drawdown observed.

A new well in Taggares County Park would be about 6,000 feet west of Well 6. Based on the observed drawdown at Wells 3 and 5, located similar distances from Well 6, we expect drawdown interference between Well 6 and a new well pumping at a rate of 1,500 gpm for two to three months to be about 15 to 25 feet. This level of drawdown interference could reduce yields from Well 6 and the new well over time. This potential could be moderated by designing the casing completion of the new well to maximize available drawdown in the Wanapum Basalt Aquifer.

A new well tapping the Wanapum Basalt Aquifer at this location would likely extend to a total depth of about 1,000 feet. Assuming a final, 16-inch-diameter completed well, cost for well construction, testing, and construction oversight would be about $700,000 to $800,000, not including costs for purchase and installation of the well pump, well house, or chlorination station. Approximate additional costs to extend the exploration about 1,000 feet into the Grande Ronde Basalt and test for yield and water quality would be on the order of $250,000 to $350,000.

Limitations

Work for this project was performed for the Varela Associates (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments

Figure 1 – Well Location Map

Table 1 – Maximum Well Yields *(in text)*

Table 2 – Estimated Annual Loss in Yield from Area-Wide Water Level Declines *(in text)*

Table 3 – DOH Source Capacity Recommendations *(in text)*

Table 4 – Estimated Interference Drawdown after Six Months of Pumping *(in text)*

Table 5 – Estimated Maximum Pumping Limited to 30 Feet of Interference Drawdown *(in text)*

Table 6 – Observed Drawdown while Pumping Well 6 *(in text)*

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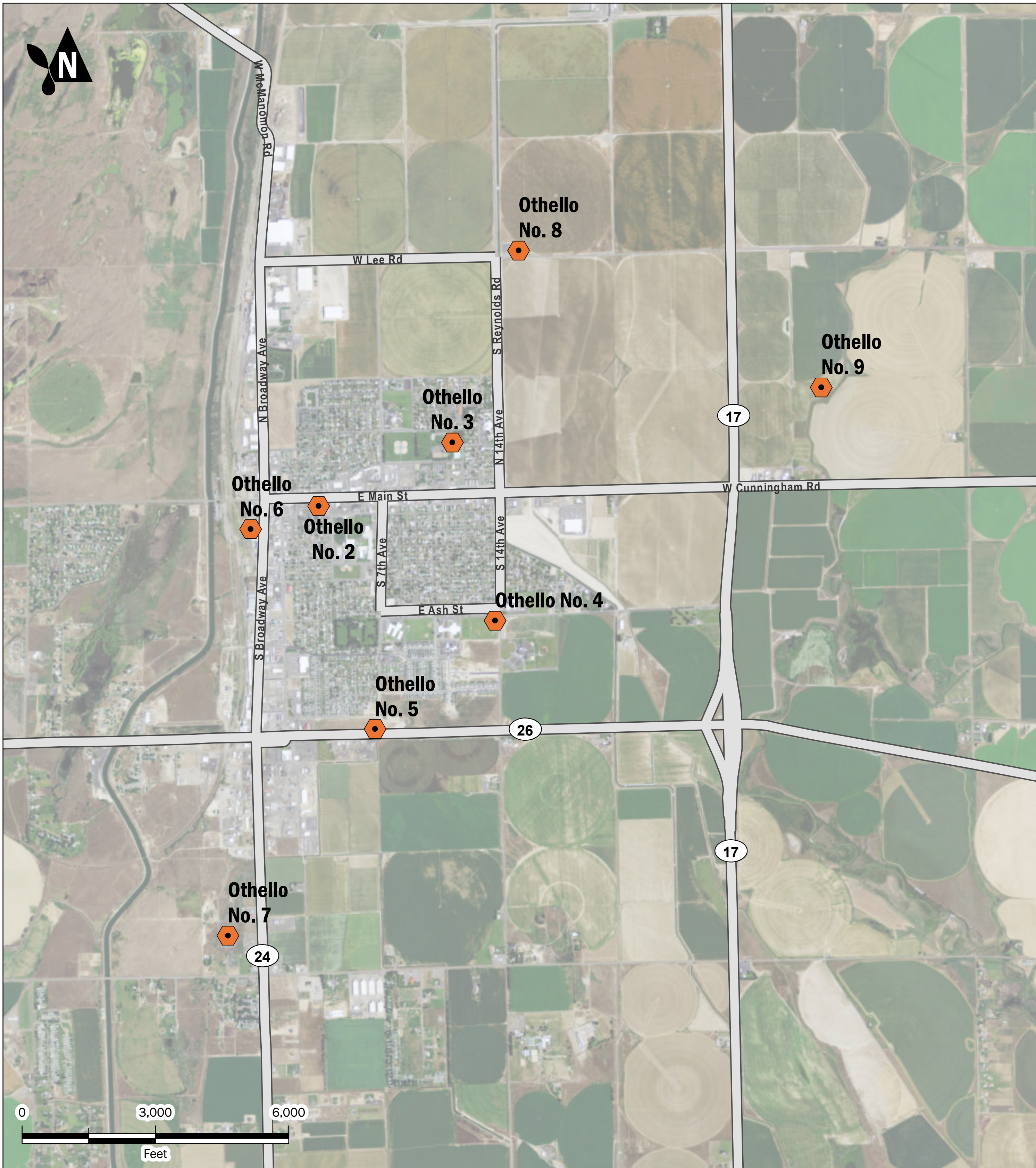

GIS Path: T:\projects_8\CityOfOthello_150143\Delivered\01 Well Location Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 5/10/2016 || User: ecrumbaker || Print Date: 5/10/2016

Well Location

Well Location Map

Varela and Associates
Groundwater Feasibility Assessment
City of Othello, Washington

Aspect CONSULTING	MAY-2016	BY: JM / EAC	FIGURE NO. 1
	PROJECT NO. 150143-001-02	REVISED BY: - - -	

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